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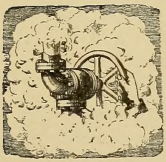
Engineering Illustrated

Volume XXI

November, 1901—April, 1902



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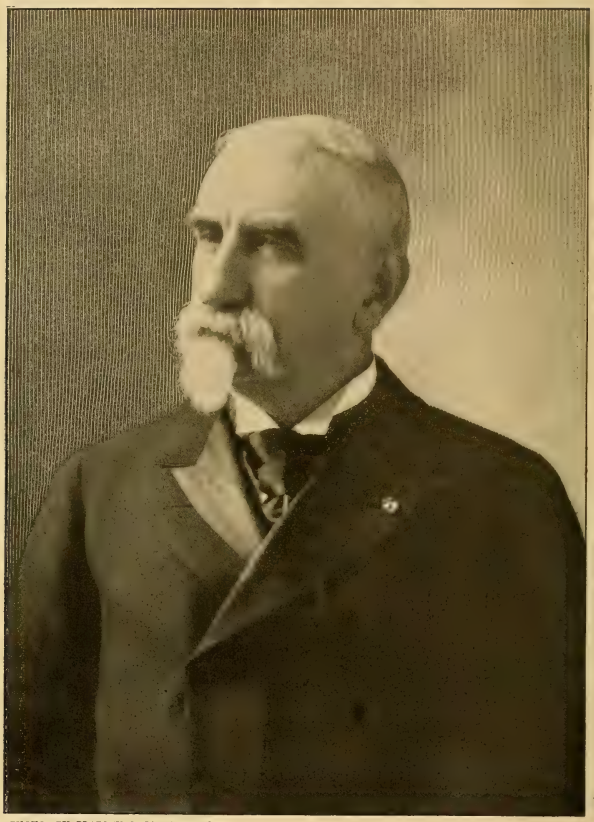

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John C. Kafer

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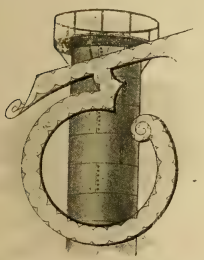
CASSIER'S MAGAZINE

VOL. XXI NOVEMBER, 1901 No. 1

THE IRON AND STEEL INDUSTRIES OF SWEDEN

By Robert W. Hunt

Captain Hunt's account, as here given, of some of the features of Sweden's iron and steel industries, is the outcome of his visit in 1899 to Sweden as one of a number of Iron and Steel Institute members. The matter, presented originally in somewhat different form as a lecture at Cornell University, was rearranged for publication here, together with a number of illustrations made available through the courtesy of the author, of Mr. Axel Wahlberg, of Stockholm, and of the Sandvik Steel Works.—THE EDITOR.



HAT far north country of Sweden and Norway has been associated with iron since the earliest times. Indeed, it seemed as though that metal was a fitting symbol for the rugged, daring, and conquering men who overthrew the peoples of more southern Europe. Iron making in Sweden goes back to prehistoric times. Hence, it is impossible to fix an exact date for the beginning of the iron age in that country; but we do know that there, as elsewhere, the first iron was reduced directly from the ores to a malleable or wrought condition. In all likelihood, "bog ores" were the only ones used, as they would have been the easiest to obtain and reduce.

It is not known when the harder and more refractory ores were first utilised, but there are documents which show that a regularly chartered company for their handling was in existence in 1303. It was not until some time toward the middle of the fifteenth century, however, that we have evidence of the manufacture of pig iron. Up to that time the iron was reduced directly to the malleable state, and called "Osmund." The mass of reduced iron was welded together by being hammered by sledges, and was afterwards flattened and cut into pieces of a somewhat standard size. These pieces were frequently used as money,—in fact, this use continued until the sixteenth century.

The introduction of pig-iron making did not for a long period drive out the direct processes, but probably soon caused modifications in them. The development of bloomery fires was on such lines. The general use of such fires is known to have existed toward the middle of the sixteenth century. The furnaces or fires were very small, and required a large consumption of charcoal and the expenditure of much labour to produce very meagre results. Åkerman tells us that about 1720 such a furnace, when in good working order, gave a daily production of about 220 pounds of Osmund iron, from which but 110 to 130 pounds of bar iron were obtained. He states, further, that as

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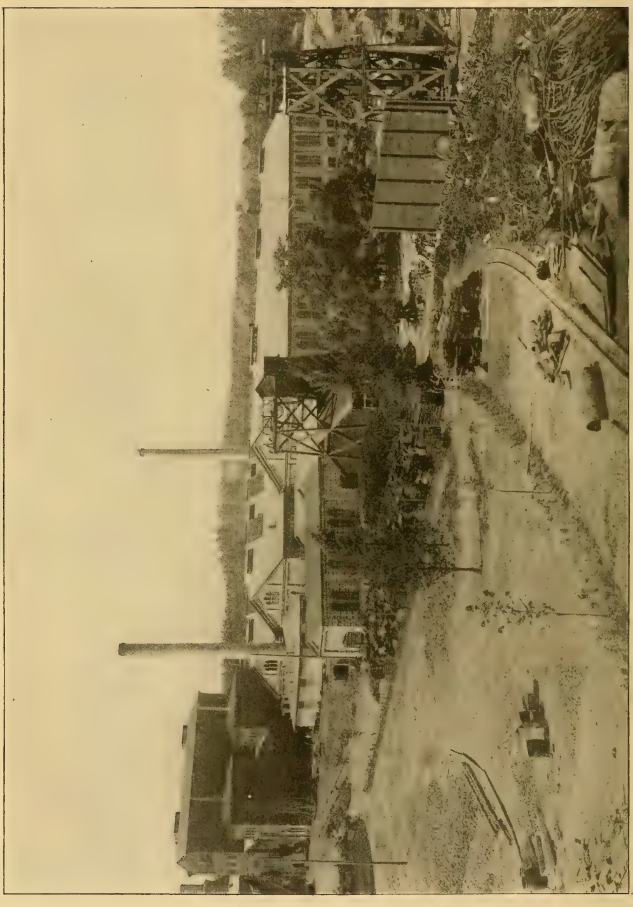


A VIEW OF THE HOFORS IRON WORKS

late as 1875 there were eight such furnaces in use in Finland. The consumption of charcoal per unit of iron obtained from lake or bog ore was five times as much as was required in the Swedish blast furnaces working in combination with Lancashire fineries, and nearly seven times as much as in the Swedish blast furnaces combined with the Bessemer process. But the ores were smelted at so low a temperature that the phosphorus was not reduced, and the resulting metal was so pure that it could be used for the most exacting purposes as iron or further manufactured into steel.

Sweden is practically without mineral fuel or coal. Fortunately, almost the whole country was covered with forests and abounded with water powers. Many of the hard iron ores are very low in phosphorus, and the charcoal from the timber contained no sulphur. The low temperatures above alluded to did not reduce the phosphorus even when the higher phosphorus bog ores were used, and hence Swedish iron and steel have obtained their wide fame for purity and excellence. Sweden exported both its Osmund iron, and bar iron made from it. The Germans were good customers, particularly for the former, which they worked into bars; but owing to want of care probably in so doing there were so many complaints about lack of uniformity that the Swedish Government enacted a law in 1655 putting an export duty on unhammered iron, thus seeking to discourage its exportation.

The Swedish kings fully realised the importance to their country of its iron industry, and several of them did much to foster it, particularly promoting the production of pig-iron; but it was not until the middle of the seventeenth century that iron made in that manner had generally supplanted the product of the direct processes. For about 180 years from this time Sweden held a most important place in the iron world, and a relatively higher one than since that time. She possessed ores low in phosphorus, an abundance of charcoal fuel, and many widely distributed water powers, but became harassed by long wars, and, what was more important, other countries were not idle, but went on developing their own iron deposits and perfecting their metallurgical processes. Among the foremost was Great Britain, and, fortunately for her, following the decadence of her iron industry, through the exhaustion of her forests, great quantities of mineral fuel were discovered within her borders, and in 1735 Darby began to use it, after coking, in blast furnaces.

Then, in 1784, Cort invented the puddling process, thereby permitting the use of the coke-made iron, which had not been as well adapted for use in the old finery fires as charcoal iron, because the greater temperature of the blast furnace had reduced the phosphorus from the ore and had also added silicon to the metal, while the coke had given sulphur to it. The struggle against foreign use of Swedish iron went on until yet another hard blow was given it in 1820 by Rogers' invention of replacing the silicious sides and bottom of the crucible of the puddling furnace by a basic one,—iron ores and slag being used. By this invention dephosphorisation of the iron was accomplished during the puddling operation. Later, in 1828, Neilson applied hot blast to the blast furnace, thus greatly cheapening the cost by making a tremendous saving in the amount of fuel used. The development of the steam-engine also afforded independence from water powers.

But Swedish iron masters and scientists had not been idle; in fact, they were among the foremost in appreciating the necessity of applying chemical science to iron making. Prominent on the roll of honour stands the name of Gustaf Ekman. He introduced, and, as Åkerman says, "nationalised the Lancashire hearth firing," and realising that the blooms so produced must have a reheating furnace, and the use of coal in Sweden being then a commercial impossibility, he developed (1840 to 1850) two types of gas reheating furnaces, one for charcoal, the other for wood. The former was generally adopted, and has

THE POWER STATION PIPE LINE OF THE HOFORS IRON WORKS

been of priceless value to Sweden. From its shape it was called, and is still known as, the "coal tower furnace." When, later, the development of railways made the importation and use of British coal possible at some of the Swedish works, this furnace was easily altered for the use of that fuel.

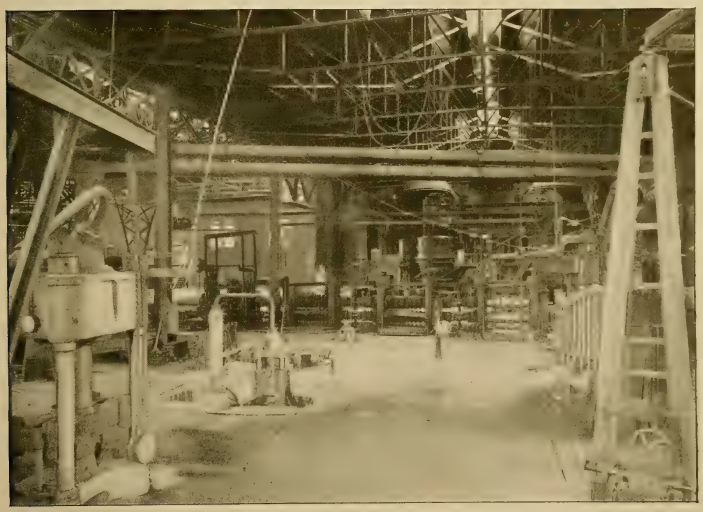
The roasting of the ores in Sweden to drive off the sulphur has been practised from early times. It was originally accomplished in piles, but as greater care became necessary through the desire to use more highly pyritic mineral, roasting furnaces were demanded. The first of these was designed in 1840 by Starback. Of course, improvements were made, and in 1851 Westman's gas furnace was designed, and has ever since remained the approved type.

We now come to 1855, when Bessemer startled the world by his invention. He was very confident that he had solved the main difficulties, and a number of British firms secured licenses from him; but it was soon discovered that experiment and practical commercial operation could be very different things. Bessemer has been hailed as a conquering king, but he was at one time even more earnestly damned as an impostor. But in Sweden, G. F. Goransson had been impressed by Bessemer's claims and entered upon a series of experiments, which led to the discovery, in the summer of 1858, that by increasing the size of the orifices in the tuyeres, and thus augmenting the volume of blast, he could shorten the process enough to produce sufficient heat in the converter to accomplish the desired end. Using, as he did, pure Swedish metal, he produced steel of most excellent quality, some of which was exported to Great Britain. Goransson's success gave fresh courage to Bessemer and his friends, and Bessemer's reputation was cleared. No doubt, with Bessemer's wonderful energy and ability, he would, sooner or later, have solved the problem. Nevertheless the writer has felt that Bessemer never made proper acknowledgment to Mushet for his recarboniser invention, and, so far as he knows, never made any to Goransson.

About 1865 the Siemens-Martin process was invented. Through this and the Bessemer process a new order

of things was established, but in Sweden supplanting of the old methods was somewhat slow. At first there seemed to be promise that Sweden, as compared to other countries, would derive great advantages from these processes, through its great deposits of low-phosphorous ores; but the Thomas Gilchrist basic process for both Bessemer and Siemens-Martin steels was invented, and Swedish hopes were once more disappointed. However, the Swedes are a hardy, intelligent and independent race, and they have manfully continued the battle. They are to-day prosperous, and the writer can see a bright future for their iron and steel industries.

Germany and Belgium now take large quantities of Swedish ores, particularly those of non-Bessemer grades, but suitable for basic processes. British iron masters can calculate the length of life for the Spanish and African deposits on which they have been relying, and are naturally casting about as to whence their future supplies shall come. South America and Sweden seem to be the only available places. At the extreme north of Sweden tremendous ore deposits have been discovered and partially developed A rich company has been, for several years, putting the property in shape, and has been yearly shipping quite a tonnage of ore to Germany and Great Britain. The company is known as the Gellivare Mining Company. The deposit is in Lapland, beyond the Arctic circle. The mines are now connected by rail to the port of Lulea, on the Baltic Sea; but a road is practically constructed to the coast of Norway, where, at the Fjord of Ofoten, there is a harbour which, owing to the influence of the Gulf stream, is open the year round. To indicate that these deposits are being effectually worked, the writer would state that in summer they employ about 2000 men, and quite 1500 in winter. The mines are about five miles distant from Gellivare, itself a florishing small town, and near Malmberg, which has a population of some 6000.



AN INTERIOR VIEW OF THE HOFORS WORKS

A view is given on the next page of

THE BERGSBO IRON ORE MINE

the Bergsbo mine, one of the workings of the Grangesberg Mining Company. These deposits are situated at Grangesberg, and have been worked for about 150 years, but not until quite recently in any but a somewhat spasmodic way. This was because of the generally high percentage of phosphorus in the ore which until the perfection of the basic processes left it without a market. The deposits occur in the crystalline schists of the primary rocks, of which the latter formation, known as granulite, contains the most ore. In this there are numerous ore bodies and lenses, running in thickness from a few inches to 300 feet. It is a tremendous deposit, and it is claimed that over 50,000,000 tons of ore have been proven. The work is mostly by open pits, but there is some underground work as well.

The field was formerly owned by various small companies, but it is now in strong hands, the principal of which is the great Stora-Kopperbergs Company. Many improvements are being installed. Among others, the magnetic reclaiming of what was formerly waste ore, by a Wenstrom plant. The electricity which is the motive power used in the whole work is brought from waterfalls about seven miles away.

The ore field is situated on the boundary of the provinces of De Larne and Westman Land, the largest and most valuable part being in the former province.

Analyses taken from the several deposits show the results given in the table on the following page.

From 1861 to the present time there has been a great increase in the production from the mines. Up to 1888 a total production of 94,114 tons was the greatest, but 1889 saw a total production of 145,596 tons, while the total for 1897 was 659,527 tons, and the year 1900 saw a proportionate increase.

As this was the writer's first visit to a Swedish iron property, made in connection with the meeting at Stockholm in 1899 of the Iron and Steel Institute, he was very much interested in the condition of the working men, and it evidently was a point on which the managers were quite anxious that their

visitors should be fully informed. To say that the writer was most favourably impressed is putting it very lightly. Here, as at other Swedish works, there is in vogue quite a paternal system on the part of the employers. In connection with this the writer would mention that tuberculosis is a disease which amounts to almost a national curse, and the government authorities, as well as those of the several industries, take stringent steps to prevent its spread. With this view, nearly all the large concerns have their own dairies, and do not permit their workmen to keep individual cows. The milk is all sterilised before being used, and every precaution is taken to keep the cattle healthy. As may be supposed, in addition to the sanitary side of the question, the workmen enjoy the luxury of most excellent milk, cream, and butter. In fact, the Swedish butter is equal to, if not the best, made in the world.

Some of the workmen's houses, owned by the mining company, are shown on this page. Each of these houses accommodates four families, two on the first and two on the second story. The dwellings are rented to the workmen on very moderate terms. They are subject at all times to the inspection of the officials.

ANALYSES OF IRON ORE FROM THE GRANGESBERG MINING CO.'S WORKINGS

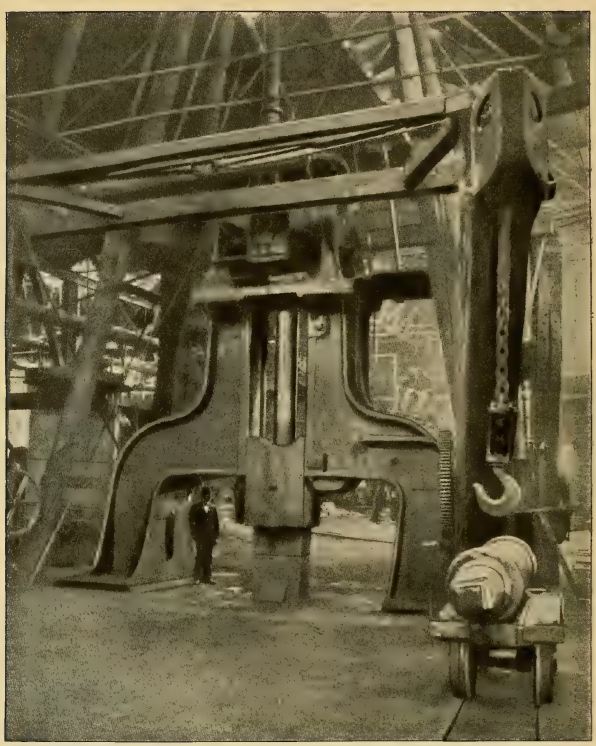
Fe O	Fe_3O_4	M_nO	M_2O	Ca O	Al_2O_3	SiO_2	P_2O_5	S	Metallic Iron	P
64.16	24.77	0.08	0.51	3.06	1.80	3.38	2.04	trace	62.85	0.89
73.50	14.81	0.04	0.82	5.09	0.63	1.62	3.53	trace	62.18	1.54
9.13	79.04	0.10	2.72	3.61	1.78	2.00	2.42	0.013	63.63	1.06
*0.32	86.54	0.13	1.69	3.50	1.64	4.82	1.90	0.013	62.92	0.83

*F_2O_3

The company own a large club building for the benefit of their people. This building is of agreeable architecture, and contains meeting, reading, recreation, bath rooms, etc. Altogether, one felt that if the lot of miners at Grangesberg was a fair sample of Swedish mining life, there could not be much but complimentary things said about it.

The next point to be visited was the Domnarfvet Steel Works. These also

WORKMEN'S DWELLINGS AT KALLFALLET



THE 15 TON STEAM HAMMER AT THE SANDVIK WORKS

belong to the Stora-Kopperbergs Company; they are the largest iron and steel producing concern in Sweden, and probably have the largest charcoal iron works in the world. The present company is of quite modern date,—1878,—but iron had been manufactured by its predecessors as far back as 1644. The plant now consists of six ore-roasting kilns, five blast furnaces, two Bessemer acid converters, three basic converters, four Siemens-Martin open-hearth acid furnaces, and nine rolling mills of various sizes.

The annual output of the Domnarfvet blast furnaces averages 43,000 tons. The production of steel ingots amounts to 51,000 tons, by which it will be seen that they do not produce all of the pig-iron consumed by them. Only the highest quality of steels are produced, it being claimed that the average pig-iron will show but 0.019 of phosphorus and 0.01 of sulphur. Water power is used. The rolling mills and blowing engines are run by directly-coupled turbine wheels; the smaller machines are driven by about forty electric motors, the current for which, of course, is also derived from water power. They now have a rolling mill which is run directly by electricity, about 2000 additional horse-power being obtained by electrical transmission from a waterfall about three miles away. At the time of the writer's visit there were about 7000 horse-power

produced at the main plant by twenty-four turbines.

The Swedish Bessemer converters are all small, five tons being quite the maximum capacity. One very striking feature about them is the contracted nose, which is in general use. The reason for this is that, as a rule, the irons are very low in silicon, and hence it is desired to retain the heat of the conversion as much as possible. The noses are placed well to one side of the vessel; this gives a reverberatory effect to its interior. Owing to this constriction of the opening for the escaping gases, the conversion produces a tremendous roaring noise.

To further obviate the danger arising from cold steel, what is known as the Casperson casting ladle is very generally used. This ladle is so designed that it can be clamped to the nose of the converter, a ganister joint being made between them. The practical result is that the steel, while being cast into the ingots, is poured through the ladle. The operation of casting begins before the whole charge has entered the ladle, the latter acting more as a sink head for the resulting castings than the receptacle for the whole charge.

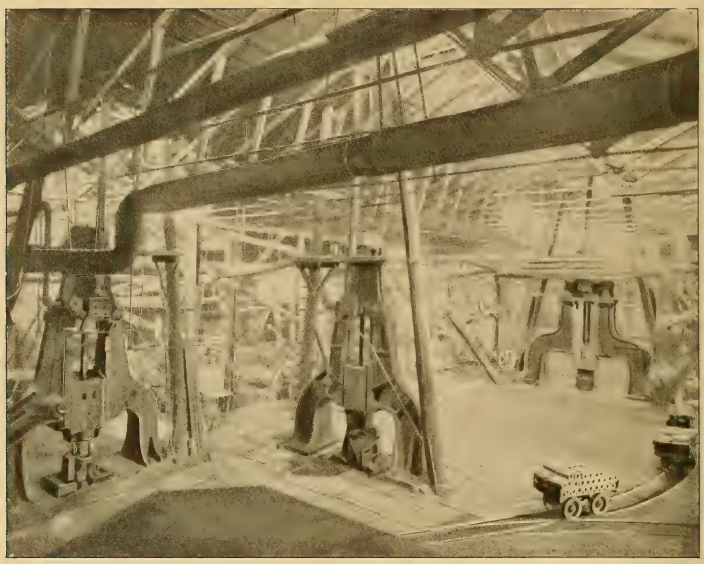
While the Domnarfvet Works are the largest in Sweden, their metallic operations, outside of being typical as to the small-sized blast furnaces and the peculiarly constructed converters, do not present any special feature of interest. They are well arranged in consideration of their capacity, and the impression given the visitor is one of good management. But beyond their metallurgical condition, the most striking feature is the utilisation of slabs and non-commercial logs for charcoal purposes. Their large sawmill plant has attached a number of upright charcoal kilns served by power conveyors, by which the wood is handled in large bulk, with the result that the charcoal is produced at a minimum of cost, especially as the by-products of the coaling process are saved. They also possess tremendous forest properties, supporting the sawmills in which the lumber is prepared for export to various foreign countries, and their refuse is utilised in these charcoal kilns, which means that their fuel for their blast furnaces is obtained at a price which, to works not so fortunately situated, would be impossible.

The night following the visit to the Domnarfvet Works was spent in the old town of Falun. There the Stora-Kopperbergs Company have established an historical and mechanical museum, the examination of which means a revelation to the visiting engineer. Mechanical devices are shown which many of us have supposed were conceived by people of our own generation; but, unfortunately for one's vanity, they have the stamp of centuries upon them.

The copper mines of the Stora-Kopperbergs Company, are among the oldest known, and have, as proudly stated by their general manager, yielded more copper than the famous Calumet and Hecla mines in the United States. But he added that they had been about four hundred years in accomplishing it. Notwithstanding the large amounts of copper which have been taken from the mines during past centuries, the company is satisfied that sufficient ore still exists to justify the installation of the most modern mining improvements.

At present the mine is 1163 feet deep, and has about 300 rooms, which, with the shafts and underground levels, amount to a length of twenty-one miles. The present annual yield is 400 tons of copper, 1600 tons of sulphate of copper, 300 tons of sulphate of iron, 2300 tons of sulphuric acid, 1000 tons of red mineral paint, 10,000 ounces of silver, and nearly 3000 ounces of gold. Practically all of the product of this mine is exported.

At present between four and five hundred employees obtain a livelihood at these mines; and in this connection the writer wishes to emphasise the fact that not only at these works, but at others in Sweden, bathing facilities are provided in the most ample manner by the companies for their workmen. There may be an impression in relation to northern people which is antagonistic to the deductions which would be drawn from this statement. But this does not



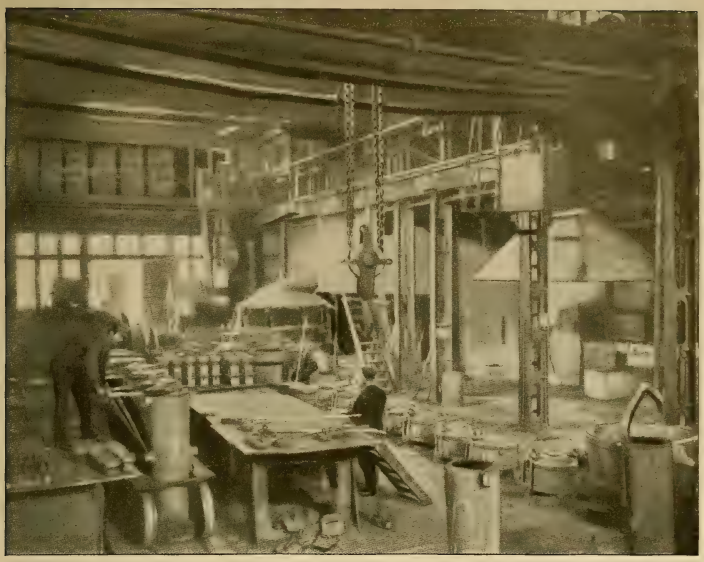
THE FORGE AT THE SANDVIK STEEL WORKS

apply to the industrial establishments of Sweden. In fact, the bath is there a national institution.

In the writer's earlier remarks the part was mentioned which the water powers of Sweden had played in its earlier iron industry, and the effect was also considered which the discovery of mineral fuel had exercised upon it. One invention is always followed by another, and so now the time is approaching when scientists can estimate the probable duration of the world's known supply of mineral coal. Thus electricity has come to play its part, and can reduce the consumption of that fuel, just as that relieved the drain on the forests of the world. So now in Sweden they call upon their water powers once more, not for direct power, but for electricity. Of this impressive exemplification was given at the Hofors Steel Works which were next visited, and that the writer might fully appreciate how this water was carried from the falls to the power producing plant, he walked over a great length of the conduit, which in its entirety extends about twelve miles. The brick power house contains six turbines, and the total power transmitted to the works by this plant amounts to 1400 horse-power.

The Hofors Works comprise two blast furnaces, two Bessemer converters, one open-hearth furnace, a blooming mill, and a wire mill. In addition, there are two hydraulic presses, several steam hammers, and the necessary supporting mechanical tools. Connected with the blast furnaces are ore roasting kilns, which are operated with charcoal. Here, as elsewhere in Sweden, most careful saving is made; the waste gases from these kilns are collected and utilised.

The Bessemer plant uses the iron direct from the blast furnaces, and blows about four tons at a charge. The open-hearth furnace is of 15 tons capacity, and the gas for it is produced from wood. The output of the plant is about 11,000 tons of pig-iron, 18,000 tons of

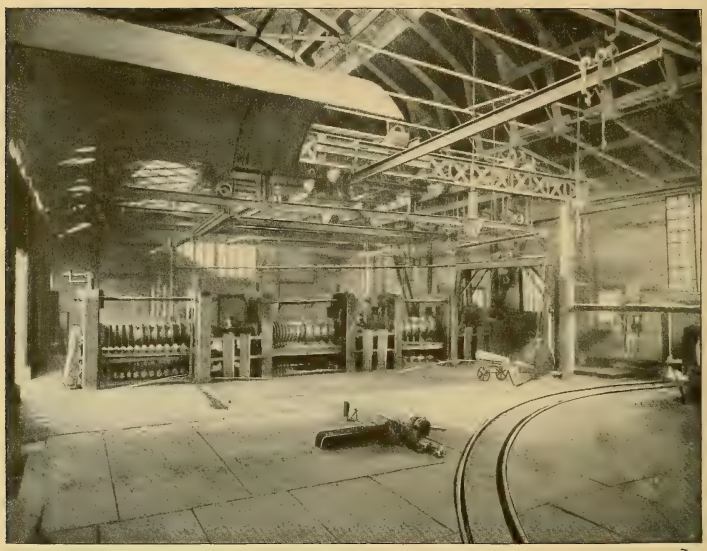


THE BESSEMER PLANT, SHOWING CONVERTER WITH ONE-SIDED NOSE

Bessemer open-hearth ingots, and a total capacity of some 15,000 tons. From this it will be seen that these works also call upon outside sources for some of their raw material. In addition to the water power before mentioned, about 1500 horse-power are obtained from other sources, and to utilise the waste heat of the furnaces they have about 500 horse-power of steam boiler capacity.

The Sandvik Steel Works, which were next visited, were particularly interesting to the writer. They were comparatively new, as they were first established in 1862. Their name comes from the creek on which they are located, this waterway being known as Sandviken, or Sandy Creek. Without having seen all the Swedish works, from the writer's observation, and from what he has been told, he has no hesitation in stating that those at Sandviken are the most modern. While the pig-iron at Sandviken has a minimum of phosphorus, and is first used in the Bessemer plant, they have established an open-hearth furnace to take care of the scrap produced by the former process, and in order to prevent concentration of that undesirable element of phosphorus, they have made the furnace a basic one. Based on this evidence of their caution and care, one can appreciate the character of their products. A few samples which the writer brought away with him ranged from the softest conceivable metal to a tool steel. This, of course, would not mean so much if one did not know that it was all made in the Bessemer converter, and the fact that watch springs are among their products show how fine the metal must be.

The Sandvik Works made their original success in the manufacture of locomotive tires, but as competition met them they developed other branches, and to-day probably their most remunerative line is the production of weldless tubing. This runs from sizes suitable for bicycles to that used for the storing and delivery of solidified gases.



THE COGGING MILL AT THE SANDVIK WORKS. THREE SETS OF ROLLS, THREE HIGH, 30 INCHES IN DIAMETER

The works were also the first to successfully develop the manufacture of flat umbrella wire for the paragon umbrella frame. Their production amounts to about 20,000 tons of steel per year, which is at present nearly all put into small sizes. For motive power there are twenty-eight boilers and thirty-five steam-engines of, together, about 4100 horse-power, and seven turbines of about 700 horse-power. The plant consists of three blast furnaces, the open-hearth furnace before mentioned, two Bessemer four-ton converters, thirteen steam hammers, ten rolling mills, a wire drawing plant, and cold rolling mills, and also a saw making and clock spring plant.

A view of the hammer shop, showing the fifteen-ton hammer in the distance, is given on page 12, and a view of the converting works on page 13. This shows the small converter with its one-sided nose, to which reference has been made. It is worth noting that the large ingots are cast on cars.

At Sandviken the writer found the same care for the men. There is a hospital in which the men have free medical attendance. The company has built four schools which have thirteen teachers, the present number of school children being 819. The company pays the expenses of the schools, with the customary contributions of the State, and the men are free from any taxation to the schools of the parish. Waterworks for household purposes are built, with water posts in every street. A bathing house is provided, where 150 men per hour can get Turkish baths and other baths as well. A benevolent society for the sick and dead exists, with 1118 members and a fund of about $3000, or about £600. A pension union also exists for old workmen and for their widows and children, with an actual fund of about $85,000, or about £17,000. The company and men contribute collectively to this fund, the company guaranteeing that if a workman dies before he gets a right to a minimum capital of Kr. 500 (about $140, or £28), it shall provide for the

amount short in this capital for the benefit of the widow and children.

Later, in the same day, we visited the Forsbacka Steel Works. This plant was originally established in 1650, when four furnaces were erected for the manufacture of iron by what was then known as the "German method." But that date has long gone by, and to-day the total production is from the Bessemer converters. Their capacity is little less than 10,000 tons per annum. There is also an agricultural implement works attached to the establishment.

As a fitting wind-up to our trip, we were taken to the great Dannemora mines. For centuries they have been to the iron maker what Mecca is to the Mohammedan. It is there that the purest iron ore commercially known to man exists. The operating company is a close corporation, and the ore is sold to no one outside of it; that is, the owners all possess iron or steel producing plants, and obtain from these mines part of their supplies. They limit the production to 50,000 tons per annum, and place it at a price which might seem prohibitory, but from its quality they can afford to so charge themselves.

The ore now comes from entirely underground operation. On the occasion of our visit the whole mine was lighted by electricity. It was like inspecting a well-ordered factory rather than a mine. Operations were suspended, excepting in one or two parts where air drills were at work, so that we might appreciate how the ore was now mined. Our visit was evidently a gala day to the town, and following the descent of the Iron and Steel Institute members to the workings, these were opened to the townspeople, men, women, and children; it was quite plain that it was, perhaps, the first opening of what had been hitherto to them a sealed chamber.

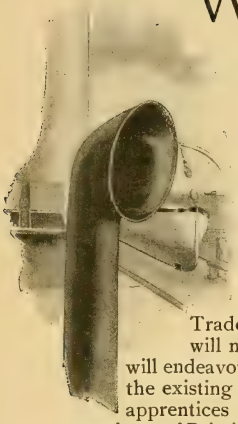
The ore is magnetite, with an average of 50 per cent. of metallic iron, and from 0.0025 to 0.005 per cent. phosphorus. It requires very little flux in the blast furnace, as the gangue is principally limestone, and the phosphorus is of that minute quantity which generally leads one to doubt the chemists' reputed results.

The mine has been operated for at least 400 years. At first it was owned by private parties, but later reverted to the government. In 1863 it was again taken by individuals, and has been successfully worked ever since. Up to 1829 the ore was disrupted by fire setting. In that year the use of gunpowder was introduced. As the present working depth is 846 feet, visiting the works seems like penetrating the bowels of the earth, and when we reflected on the great age of the mine and the primitive character of its first exploiting, we could not help feeling that from some dark corner might come the spirit of the ancient Norseman to ask why we were intruding upon its original home.

TRAINING APPRENTICES

IN THE ROYAL DOCKYARDS OF GREAT BRITAIN

By Frank Barter, M. Inst. N. A.



WITH the of late frequently alleged waning industrial supremacy of Great Britain two things have been persistently brought forward as mainly contributory to it,—the evil influences of misguided trades unionism, and the faulty methods practised in educating the workers in technical matters. Trades unionism the writer will not discuss here, but will endeavour to deal briefly with the existing methods of training apprentices in two of the most prominent of Britain's industries,—shipbuilding and engineering,—and with the system of education adopted by the British Admiralty for the apprentices of the Royal Dockyards, and to contrast this latter with what is done by private employers for their apprentices.

The fundamental conditions which govern the two classes of apprentices are, of course, very different in character. Broadly speaking, we may put it thus:—In the private shipyard or engineering works the apprentice is regarded by his employers mainly in the light of a profit producer, and in return for his services as such he is permitted to learn the business up to the point of making a workman of himself. In the royal dockyard, on the other hand, the apprentice is regarded in the light of a student as well as a "trade" apprentice, and he is educated by the government in both senses. Practically unlimited facilities are afforded him for the acquisition of the most useful education obtainable,—scholastic as well as technical.

The proprietors of private establishments cannot, seemingly, afford to do much more than train their apprentices to become good workmen. Even the additional advantages enjoyed by what are called premium apprentices are usually of a merely departmental character, while the young men are left pretty much to their own resources and inclinations in the pursuit of purely educational studies.

Having thus broadly indicated the distinctive circumstances which govern the training and education of the two classes of apprentices, let us study the matter somewhat more in detail. To begin with the apprentices of private establishments, the boy whose parents cannot afford to pay a premium has little chance, in the great majority of cases, of learning the entire art of shipbuilding, for example, but must of necessity be content to select one of the many "trades" into which that industry is divided,—that is to say, he must decide to become either a ship carpenter, or a boatbuilder, or a plater, or an anglesmith, or a loftsman. If he have a fair knowledge of elementary mathematics and a liking for drawing, he may, perhaps, wish to become a draughtsman, but even in this department he is sometimes called upon to pay a small premium.

On the other hand, the boy who desires to become a shipbuilder in its broadest sense must spend a portion of his apprenticeship in each of the several departments or "trades" already enumerated; but, in the great majority

of cases, a heavy premium has to be paid for such facilities, varying from £50 to as much as £750.

The same circumstances usually prevail in the engine department. The boy who wishes to learn engineering in its complete sense must pay a premium. If his parents cannot do this he must decide to become either an engine-fitter or a turner, a pattern-maker, a boiler-maker, a coppersmith, or perhaps a draughtsman.

It is not proposed here to enter into a discussion of the ethics of premium-paying, because it is not strictly within the limits of the subject under review. As already intimated, however, whether a premium has been paid or not, the proprietor of a private establishment, in the great majority of cases, fulfils his contract with his apprentice by teaching him (perhaps I should rather say,—allowing him to pick up) the purely practical or mechanical part of his business, and undertakes no responsibility for his training in technical studies which are indispensably a part of the complete education of the practical shipbuilder or engineer.

Now let us turn to the apprentices of the Royal Dockyards! At the outset it should be explained that the Admiralty exacts no premiums, but a civil service examination, preceded by a medical examination, has to be passed in the following subjects before a boy can be received into a government dockyard:—

Arithmetic.—The whole of the subject usually taught in public schools, except cube root.

Orthography.—Two selected pieces of dictation, to be done in a given time.

Handwriting.—Usually a paragraph containing a tabular statement of statistics.

Geography.—Of the world, particularly of Great Britain and her colonies.

English.—Including analysis, syntax, etymology, etc.

English Composition. — Moderate proficiency.

Algebra.—Up to and including simultaneous and quadratic equations.

Geometry.—Books I., II., and III. of Euclid, with deductions thereon.

Arithmetic, orthography, and handwriting are compulsory subjects, the others being optional; but perhaps I need hardly say that the candidate who takes only the "compulsory" subjects never gets in. Every successful candidate is given the choice of his profession according to his position on the merit list, and, upon appointment, receives an instructor, whose special duty is to guide and instruct him in the purely mechanical operations of his business,—shipbuilding or engineering, as the case may be. These instructors are (or, rather, should be) skilled workmen of good character, who are selected by the superior officers of the dockyard, and receive an extra two shillings a week for the first four years of the lad's apprenticeship.

Each apprentice is bound by an indenture of a rather elaborate character to serve for six years "after the manner of an apprentice, for the use and benefit of His Majesty, His Heirs, and Successors." He further binds himself not to absent himself from service without leave, "nor contract marriage during the period of his indenture, nor be guilty by word or action of any immoral, indecent, irregular, or improper conduct or behaviour in any respect whatsoever, but shall and will demean himself at all times with strict propriety and submission to his superiors."

The father or guardian of the apprentice binds himself in the same indenture to "provide good and sufficient board, lodging, clothing, washing, and other necessaries proper for his personal accommodation and benefit, and suitable to his intended situation; and also all such implements, working tools, and instruments as shall be requisite to enable him to learn and practise his art."

These quotations may not, perhaps, be considered strictly relevant to the subject under review, but their introduction at this stage may interest those who are unacquainted with the terms of "indentures of apprenticeship."

I propose first to explain the nature of the practical training given to the government apprentice. It will be in-

ferred from my previous remarks that the apprentice enjoys the constant companionship of his "instructor" for the first four years of his apprenticeship, after which he is expected to work as a "mate" with any mechanic to whom his inspector may appoint him. In the shipbuilding department the apprentice is afforded facilities for acquiring an intimate knowledge of all the operations of construction, from the preparation of the blocks for receiving the keel to the finished sea-going condition of a ship. He is taught to prepare and erect the framework of the vessel, to template and fit in place the steel plating of shell, decks, and watertight compartments, and to test these compartments. He learns how to make and fit watertight doors and their appliances, sluice valves, in fact, all the work involved in fitting out a ship with pumping, flooding, draining, and ventilating arrangements, except such work as legitimately belongs to the coppersmith, or blacksmith, or moulder. It will thus be seen that the young shipbuilder acquires an intimate knowledge of the treatment of steel and ironwork, and skill in the use of the appropriate tools.

The various operations and details of work which have so far been enumerated, collectively constitute the art of building a modern steel ship; and remembering that this work in private shipyards is divided amongst several classes of skilled workmen, as framers, platers, loftsmen, fitters, etc., it is manifest that the modern dockyard apprentice has a much wider scope for the exercise of his energies than the private yard apprentice.

It should not be inferred, however, that the present-day dockyard apprentice is not a woodworker as well as a metalworker. That is by no means the case, for he has to make himself proficient in all the woodwork usually done by ship carpenters in private establishments. That is to say, he is taught to prepare and lay deck planking, to fit up storerooms and magazines, launching arrangements, etc., and occasionally to build composite vessels.

The practical operations of dry-docking and undocking ships, and general repair work both in dock and afloat, constitute another important branch of his training.

Up to a few years ago the dockyard apprentice received twelve months' training in the ship-fitter's, or millwright's, shop, where he was taught to use the lathe, slotting and planing machines, and engineering tools generally; but this has now been discontinued, presumably in consequence of the militant attitude of modern trades unionism. The term of apprenticeship has also been reduced from seven to six years.

So much, then, for the training given in the practical work of the shipyard. In addition to this, facilities are provided for instruction in ship drawing. Evening classes are conducted in the dockyard drawing offices by the chief draughtsman, but attendance at these is quite optional. Those who attend the class for a year are selected by rotation for six months' day instruction in the drawing offices and mould loft, and this period of instruction usually comes during the fourth or fifth year of apprenticeship. Certain of the apprentices, however, receive twelve months' day instruction in drawing, to which further reference will be made later.

Apprentices who display a special aptitude for drawing are sometimes retained in the drawing office (or "borne out on drawing duties," as it is termed), and receive appointments as draughtsmen as vacancies arise or the exigencies of the service demand, after passing the necessary competitive examination in practical and theoretical naval architecture.

The apprentices in the engineering department are given similar facilities as those in the shipbuilding department for the acquisition of a thorough knowledge of the business, and every such apprentice likewise receives an "instructor." I am not so intimately acquainted with the practical training of apprentices in the engineering shops as with those of the shipyard, but I think I am correct in saying that all apprentices spend some part of their appren-

ticeship in the turning shop, erecting shed, pattern maker's shop, boiler shop, iron foundry, brass foundry, coppersmith's shop, and "finishing" shop. Their instruction in drawing is precisely similar to that given to shipyard apprentices. Some of the apprentices get opportunities for working in the "torpedo" shop, and in the "ordnance" department, although apprentices generally cannot claim such facilities by right.

As to the purely educational training provided for dockyard apprentices, each of the five dockyards has a training school with a library attached. The school is divided into two classes—an "Upper Division," for apprentices in their third and fourth years, and a "Lower Division," for first and second-year apprentices. Each division attends school two afternoons and evenings a week for general study, and on Wednesday evenings for laboratory experiments and science lectures. All text-books are supplied by the Admiralty, and include the best standard works on professional subjects.

Examinations, lasting from three to six days, are held every six months, and the results are published in the order of merit. Apprentices who do not obtain a specified percentage of the maximum marks, or whose conduct or diligence is not satisfactorily reported upon, are not permitted to continue at school. Consequently there is an annual weeding out of deficient ones.

The greater number of apprentices leave school at the end of their third year, and some have to leave at the end of their second, or even their first year Those of special merit remain at school during their fourth year, and are attached to the drawing office for twelve months, that is, during the whole of their fourth year, under the guidance of a draughtsman "instructor." At the end of this time they are examined in the subjects of the "Upper Division" course of study, which will be referred to further on.

Usually the best two or three apprentices on the fourth year list then proceed to the Royal Naval Engineering College, at Devonport, to continue study during their fifth year, either as "students of naval construction" or as "engineer students," according as they are in the shipbuilding or engineering department.

The subjects of examination for apprentices in the "Lower Division" (first and second-year apprentices) are:—

Arithmetic and mensuration	400 mks.
Algebra	400 "
Geometry (Euclid's Books I. to VI., XI. and XII., with deductions)	500 "
Trigonometry	500 "
Statics and hydrostatics	600 "
Physics (light, heat, magnetism and electricity)	600 "
Chemistry	300 "
French (optional)	400 "
Geography and English history	400 "
Total	4,100 "

First-year apprentices must obtain at least 40 per cent. of this total to be permitted to attend school during their second year. Second-year apprentices must obtain at least 60 per cent. to be permitted to continue during their third year, when they become "Upper Division" students.

The subjects of examination for the "Upper Division" are:—

Statics, hydrostatics and hydraulics	500 mks.
Dynamics	500 "
Applied mechanics	500 "
Higher algebra and trigonometry and elementary conic sections	500 "
Differential and integral calculus and conic sections	700 "
Descriptive geometry (*or* mechanism)	400 "
Physics (light, heat, magnetism and electricity)	700 "
Chemistry	400 "
Naval architecture (*or* engineering)	2,400 "
Total	6,600 "

A third-year apprentice must obtain at least 40 per cent of this total to continue study during his fourth year, and, as before remarked, the best two or three of the fourth-year apprentices proceed to the engineering college at Devonport to continue study during their fifth year. A fifth-year apprentice will be either nineteen or twenty years of age, and the final examination at the end of the fifth year is of a very difficult character, as will be seen from the list of subjects below. There can be no two opinions as to the intellectual brilliance of those apprentices who can pass a satisfactory examination in such a list of advanced subjects. They are:—

General paper in elementary mathematics and mensuration	500	mks.
Statics, hydrostatics and hydraulics	500	"
Dynamics	500	"
Chemistry	400	"
Physics ((*a*) heat and light; (*b*) magnetism and electricity)	700	"
Applied mechanics and graphical statics	500	"
Descriptive geometry	400	"
Advanced algebra and trigonometry	500	"
Conic secions, and differential and integral calculus	700	"
Practical physics	300	"
Heat, combustion and metallurgy	800	"
Practical Shipbuilding—Part I	1,000	"
" " Part II	1,000	"
Shipyard machinery—Practice and appliances	600	"
Ship drawing	600	"
Laying off and mould practice	1,000	"
Total	10,000	"

In the place of the last six subjects of this list engineer students take:—

Theory of mechanism and machinery.
Steam and the steam engine.
Practical engineering.
Workshop appliances and practice.
Mechanical drawing.
Design of machinery.

Those who pass this examination satisfactorily proceed to the Royal Naval College, at Greenwich, to continue their studies in the above-named subjects, with the addition of papers on theory of waves and propulsion and stability and oscillation of ships.

Apprentices who obtain at least 75 per cent. of the maximum marks in the "Upper Division" examination are permitted to retain their books on the completion of their school course, and as the full "Upper Division" course of study requires between forty and fifty text-books, worth from £15 to £20, it is evident that they are worth working for.

Prizes are awarded annually by the Lords of the Admiralty to the most distinguished apprentices in each division, the first prize in each division being known as the Admiralty prize. All apprentices attending school are granted three days' holiday after the summer examinations. Fourth-year apprentices (*i. e.*, those who have taken the final "Upper Division" examination) get a week's leave.

It will thus be seen that the educational training provided for the apprentices of the Royal Dockyards is as thorough as the practical, and it is also clear that apprentices who wish to get on can and do get on.

It might appear to some that the lad who "goes through" such a wide and varied course of training as has been here set forth must be a sort of "Jack of all trades, and master of none," or that he will be either a good scholar or a good mechanic. It should be remembered, however, that whereas the term of apprenticeship in private establishments is limited almost universally to five years (and in some districts to only four years), the dockyard apprentice serves six years, and until recently served seven years; and it should be also borne in mind that most lads of ordinary intelligence will learn more of their business during their fifth and sixth years than during their first, second, third, and fourth years put together.

The writer, who was in the Admiralty service for nine years, and has since been for several years in daily intercourse with private establishments, can testify to the superior "all-round" fitness of dockyard trained workmen, as compared with men who have been trained in private establishments. Furthermore, the highest professional positions in the country are held by men who receive their training in the Royal Dockyards; for example, the higher positions of the Admiralty, the marine department of the Board of Trade, Lloyd's Registration Society, and of many of the leading shipbuilding and engineering establishments. The current standard works on professional subjects have nearly all been written by dockyard trained men, Sir William H. White, for example, Sir Edward J. Reed, Messrs. Thearle, Sennett, Seaton, Welch, and others.

The provision of such a training for the apprentices of private establishments seems nowadays to be impracticable on account of the expense which it would entail. To some extent this difficulty is met by the Department of Science and Art, South Kensington (or the "Board of Education," as it is now called), which encourages the establishment of evening classes in science, art, and technology, and of which a large number of apprentices (both dockyard and private) take advantage.

It is a very regrettable circumstance,

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however, that the proprietors of private shipbuilding and engineering establishments of Great Britain, speaking generally, take little interest in the technical education of their apprentices. I say speaking generally, because there are a few singularly conspicuous exceptions. The most notable case which occurs to me at the moment is that of Messrs. William Denny & Brothers, of Dumbarton. The evening classes in science and art at Dumbarton are largely subsidised by the members of this world-famed firm, who take a fatherly interest in the intellectual welfare of their apprentices, akin to that which they are known to take in the moral and social welfare of all their employees. All apprentices are encouraged to usefully employ their evenings by attending the local classes in science and art. The fees are merely nominal, and are returned to those who attend regularly and pass their examinations. Messrs. Denny have established a well-stocked library of scientific works in connection with their shipyard drawing office, open to all their draughtsmen.

They refuse premiums, preferring apprentices with brains rather than money. Those apprentices who wish to enter the drawing office with the view of becoming draughtsmen are expected first to serve about two years in the shipyard, should have passed the elementary stage of naval architecture, and must be of good character. Every apprentice in the drawing office of the shipbuilding department is given, as far as practicable, a year in what is called the "Scientific Department."

The writer had the honour of serving Messrs. Denny in this department some years since, and, coming to them direct from a government dockyard, could not fail to be struck with admiration at the atmosphere of smartness and loyalty which pervaded all departments of this great establishment, and in this respect Messrs. Denny, doubtless, consider themselves well repaid for their interest and encouragement. There are a few other important firms in the country who are known to emulate this example, though by no means to the same extent.

While shipbuilders and engineers cannot be expected, generally speaking, to put themselves to the expense of educating their apprentices as thoroughly as the Admiralty do, there is certainly nothing impracticable about the example set by Messrs. Denny & Brothers, an example which is a very creditable distance from the absolute indifference which too generally characterises British employers with respect to the technical education of their apprentices. There is no doubt in my mind that much of the existing pessimism as to loss of commercial prestige with which Great Britain seems to be threatened would be removed if shipbuilders and engineers would bestir themselves to take more interest in the intellectual welfare of their apprentices, or, for that matter, their employees generally. When this happens, employers will find it as much to their profit as to their credit.

It will be an appropriate conclusion to quote the following remarks which were recently made by Sir William Hart Dyke, at the annual meeting of the "Association of Technical Institutions." He said:—"Our Continental neighbours, owing to their efforts in the direction of technical instruction, are obliterating the wide gap which once existed between them and ourselves in regard to commercial supremacy. Our splendid commercial position before the world, in spite of our resources and the energy of our people, is giving way, inch by inch, to the subtle influence of the superior educational system of other nations. We must recognise that the day of the untrained man has gone by. It is imperative that we should give some kind of technical education to all our children."

LARGE ALTERNATORS

By Robert S. Ball, Jr.

SINCE the epoch-making discovery of electromagnetic induction which marked the commencement of a new branch of practical engineering, the alternating-current generator has made steady progress. Much scientific thought and practical skill have been associated with the evolution of this type of machine, with the result that the design and construction of large machines is now accomplished with an assurance that the calculated output and voltage at a given armature speed will closely follow the predictions of the mathematician.

Both alternating and direct-current generators are alike in that alternating currents are produced in both by the passage of the armature coils through a field of alternately varying polarity which induces currents of alternately varying direction in the coils. Where it is desired to supply a direct current the commutator is added, and the machine thus encumbered by an unmechanical device becomes a direct-current generator. This statement, elementary as it is, helps to fix the relationship between alternating and direct-current generators. It shows that the latter type of machine is an outgrowth from the former by the addition of an automatic switch, as the commutator might properly be called. It is difficult for the layman to compass the fact that the alternator is a simpler machine, mechanically and electrically, than the direct-current generator. He would naturally assume that the alternating current which surges to and fro in the circuit would be derived from a machine of exceeding complexity, while the direct current, like a stream of fluid in a pipe, would emanate from an electrical engine of comparative simplicity.

If the difficulties connected with the generation of electric currents included all the obstacles which had to be overcome, doubtless the alternator, in view of its comparative simplicity, would have been universally employed, to the exclusion of the direct-current generator: but the practical impediments which for a long time stood in the way of the utilisation of the alternating current were of such an obstinate nature that the direct current has become very popular, and still remains so for purposes to which the alternating current has not yet been successfully applied. The invention of the induction motor, the alternating arc lamp, and other devices for utilising alternating currents direct gave a strong impulse to the design of alternators by extending to an indefinite extent the field of application open to the use of their output.

Besides the comparative simplicity of the alternator as a machine, there are advantages attendant upon the use of alternating currents which cannot be passed over unnoticed if we are looking for the *raison d'etre* of the extraordinary increase in the number and size of alternators now on the market. The principal advantage is undoubtedly the fact that the voltage in an alternating-current system can be varied at will to suit the needs of special applications by the aid of the static converter. It is also possible to change the pressure in direct-current circuits by the wasteful process of absorption of energy through a resistance in series, but such a course is, to all intents and purposes, a poor makeshift, and is prohibitive from a commercial standpoint. The static converter, on the other hand, transmits nearly all the energy with which it is charged, the only losses being small copper and iron losses which, together, amount to a small proportion of the

total energy passing into the converter. In large converters these combined losses amount to about 3 per cent. of the capacity of the converter, and even in small sizes of the best kind the losses are so small as to confirm the statement that the alternate-current converter is the most efficient device known to the engineer. The reducing valve on a steam pipe, which takes the place of the converter in the apparatus of the steam engineer, is far more wasteful of the energy which passes through it with a reduction of the steam pressure. With the assistance of the converter the electrical engineer can transmit current over long distances by raising the voltage, and thus diminish the cost of the copper line, for this latter varies inversely as the square of the voltage. The advantages are all on the side of high pressures within the limits of good insulation, and this has been met by some radical changes in the design of alternators, introducing methods by which failure under great dielectric stress may be avoided.

The voltage delivered from a generator is dependent upon the relative linear speed of the armature coils and field, the strength of the magnetic field, and the number of turns in the coils of the armature, so that an alteration in any of these quantities for a given machine makes a corresponding change in the voltage. The first of these,—the linear speed of the armature coils,—varies with the number of turns and the diameter of the rotating part of the machine, but modern practice shows that the tendency is to keep the speed of the machine low, as there are mechanical difficulties incidental to high speed which have pointed to a safe maximum. The early belt-driven machine with a small armature has been almost completely supplanted by the direct-connected set, the alternator having a rotating part of comparatively large diameter running at a speed approaching that of a large marine engine, the increased diameter compensating for the reduced number of rotations.

A few facts and figures prove that little alteration has been made in the linear speed of the coils such as might be supposed by the change from belt-driven to direct connected alternators. The practice of to-day varies from 3000 to 5000 feet per minute, which is seldom exceeded, except in the turbo-alternator, where the armature is direct-connected to the fast-running turbine. The mechanical strains induced by centrifugal force have necessitated a strong construction in rotating armature machines to prevent the coils from breaking loose. The old method of employing binding wire surrounding the armature in which the coils are laid in slots cut in the laminations parallel to the shaft is no longer employed in large direct-connected alternators. They are now generally secured by wedges of fibre or other material, which effectually prevent displacement under the severe strain to which they are subjected.

The strength of the magnetic field in which the coils move is limited by the saturation of the metal of which the poles are formed. Usually these are constructed of thin sheet steel punchings, bolted together and secured to the frame casting in rotating armature machines, or to the spider in rotating field machines. The point of saturation is not reached under the field excitation at full load in order to leave room for the necessary regulation by changing the exciting current.

The high voltage obtained in modern alternators is due to improved methods of winding and disposition of the armature coils. It might almost be said that the term "winding," as applied to armatures, is no longer a correct expression, as the old labourious method of winding by hand has been superseded by machine-made coils which are carefully insulated, and, after baking, are subjected to a puncture test of several thousand volts before they are fitted into the accurately made slots in the armature core, this latter operation constituting the work of the armature winder. These coils are largely made of copper strip pressed into the required shape over a mould or former, and then wrapped with the insulating material

and carefully inspected. Each coil is thus independent in the sense that it may be quickly replaced should such a course be necessary in case of failure by undue strain.

The rotating field alternator is rapidly growing in favour for high voltages. In this machine none of the rotating parts are at a high potential, for the rotating spider carries the laminated pole pieces surrounded by the field coils to which a low-voltage direct current from the exciter is carried by slip rings on the shaft. The voltage generated in the stationary armature conductors by the rotation of the field is precisely the same as that which would be induced in them if they were rotating at the same speed in a stationary field, for it is the relative speed of field and armature that effects the voltage. With the armature coils stationary, a high degree of insulation can be attained, for they are not subjected to mechanical strains and are more readily inspected. This plan was used in the construction of the 5000-H. P. alternators at Niagara, but in this case the rotating field surrounded the armature, the former being mounted direct upon the vertical turbine shaft.

The electrical industry has shared in the general tendency towards concentration of capital into large enterprises. The supply companies to-day in the large cities are continually augmenting their plant, and the generating sets which they require from manufacturers are larger than ever before. All this tends towards economy in operating expenses, for the larger the units, the greater the efficiency; or, in other words, a larger percentage of the energy in the coal is converted into electrical energy by large generators than by those of smaller size. As a converter of energy, the large alternators built to-day are highly efficient, for it is possible to obtain 94 per cent. of the mechanical energy in the form of electrical energy at the terminals of the machine. Of the entire plant, consisting of boilers, engines, and generators, the last are the most efficient part; the greatest loss in converting the latent energy in the coal into electrical energy occurs in the steam plant. The successful driving of alternators in parallel is a problem which is shared by the electrician and the mechanical engineer. In direct-current installations dynamos may be connected to work in parallel without any difficulty. If the machines are made from the same pattern and driven separately, a difference in the speed may be counteracted by adjusting the field of each machine so that the voltage across each is the same, and this is the only requirement to ensure successful operation. In paralleling alternators, however, it is not only necessary that each machine shall generate at the same voltage, but that the speed, upon which the periodicity depends, shall be the same. It is fortunate for the steam-engine builder that alternators in parallel have a strong tendency to keep in step, otherwise the problem of paralleling would be impossible, for the most carefully adjusted governor would be unable to prevent the very slight variation in angular velocity which would be sufficient to destroy harmonious working.

In direct-connected sets the heavy weight of the armature or rotating field, as the case may be, serves to play the part of a fly-wheel, though often it is supplemented by an independent fly-wheel on the shaft. Engineers are divided in their opinion concerning the expediency of making the armature of large alternators heavy enough to have the full fly-wheel effect. Ventilation of the armature core must always be an important consideration, and great weight in the armature necessitates substantial bearings to prevent wear and consequent sagging. The effect of the rotating part becoming out of centre is to impose a great extra strain due to the unbalanced magnetic pull. This force is measured by several tons for a displacement as small as one-thirty-second of an inch in large machines. It is customary, in erecting, to make the air gap on the upper side somewhat less than that on the lower to allow for the inevitable displacement due to wear under running conditions, so that, when the bearings become worn down to a

good surface, the armature and field will be concentric.

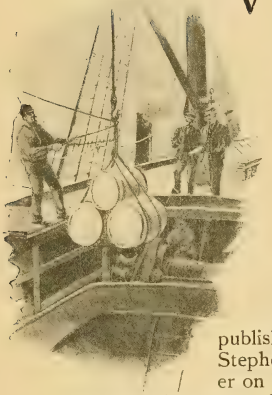
The regulation of alternators cannot be effected in the same manner as that of direct-current generators. In the latter the compound winding of the field maintains the constant voltage, but the pressure in an alternating circuit cannot be automatically kept constant by such means. The tendency to variation in the voltage is due to the fact that the armature current demagnetises the field as it increases, so that for heavy loads the field is weakest. On non-inductive loads a variation of less than 10 per cent. is attained by the best machines. This is largely effected by having a large number of armature slots per phase per pole, thus decreasing the self-induction.

We have not yet reached the limit of size in large alternators, for each year we hear of larger machines being projected or under construction. The largest ever projected, and which are now under construction, are of 10,000 electrical horse-power. These machines, of which there are eight, are designed to furnish current to the Manhattan Elevated Railroad, of New York City. They deliver a three-phase current at 11,000 volts, which will be reduced in static converters and then converted by rotaries into a 500-volt direct current for use on the line. The height of each machine is 42 feet, the calculated weight 889,000 pounds, the diameter of the revolving part 32 feet, and its weight 370,000 pounds. They are direct-connected to multiple-expansion steam-engines of corresponding size, and the entire plant will, doubtless, show an efficiency unattained up to the present.

BRITISH CARGO BOAT MACHINERY

TWENTY YEARS' PROGRESS

By J. F. Walliker



VERILY, the history of marine engineering in general for the two decades terminating in 1879 is the history of the adoption and triumph of multiple expansions and of high pressures. It is stated in Chambers' "Information for the People," published in 1849, that Stephenson saw a boiler on board an American steamboat on the Ohio River worked at 138 pounds pressure. This is certainly some years before we have any record of such in Great Britain. At the same time, it is well to remember that high pressures were not unknown there in the latter part of the seventies, but had been in a sort of suspended condition for a number of years.

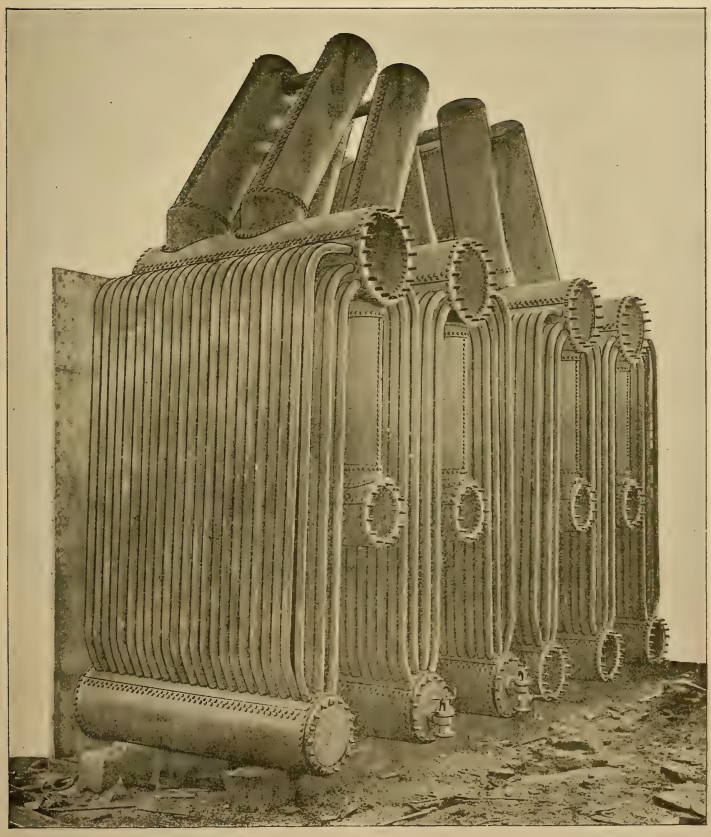
Looking through the pages of Lloyds Register for 1879, we find a few cases bearing on this question of dates and pressures. There can be found recorded the little *Enterprise*, engined by Wilson, of London, in 1872, with a pressure of 150 pounds; the *Sexta*, of 1874, with a pressure of 120 pounds, and with triple-expansion engines working on three cranks; the *Propontis*, engined in the same year by Messrs. Randolf & Elder, of Glasgow, likewise fitted with triple-expansion engines, and others. Mr. Perkins' tri-compounds came out about the same period,—the yacht *Isa*, in 1879, with a pressure of 120 pounds, and a few others of which the data are uncertain. With the single exception of the *Isa*, all the others may be well designated as experiments that failed, and it was owing to the success of this little yacht that the possibility of the ordinary boiler for still higher pressures suggested itself.

That the boiler alone was the weak spot in all the earlier engines designed for high pressures is well typified in the history of the *Propontis*. Built in 1864, she was re engined and fitted with tri-compound engines and new boilers in 1874. These boilers, which were of the water-tube type, were a failure. They were taken out in 1876 and replaced by ordinary boilers working at 90 pounds pressure. These were again renewed in 1885, with a pressure of 145 pounds, and the vessel is still running with these and with the 1874 engines! This difference, or improvement, is clearly due to the boiler factor alone, and on this point Dr. Kirk, at a meeting of the Institution of Naval Architects a few years ago, expressed his conviction "that the want of a proper boiler had delayed the introduction of triple-expansion."

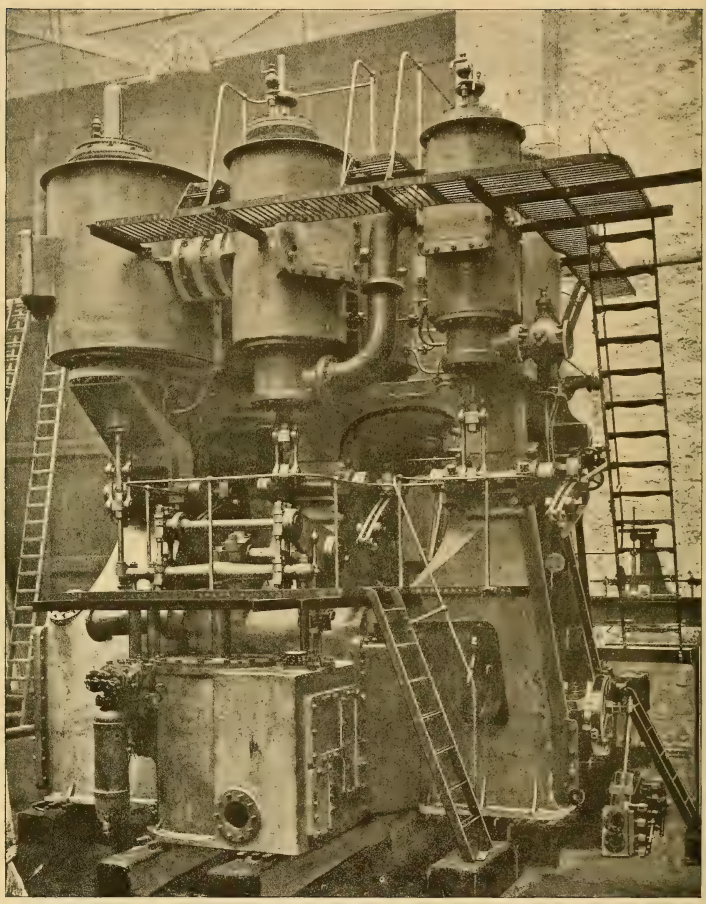
The credit of introducing what at the time, and since, fulfilled that want to a most satisfactory degree, it is believed, is due, firstly, to Mr. Alexander Taylor, of Newcastle-on-Tyne, in adapting the ordinary boiler to the higher pressures; and, secondly, to Messrs. Fisher, Renwick & Co., of the same town, for their enterprise and foresight in fitting it into one of their vessels, the commercial success of which brought the triple-expansion engine, once and for all, from

the rank of experiments to deserved general recognition.

Thus, to the much maligned multi-tubular marine or Scotch boiler we owe the adoption of the multiple-expansion engine of to-day. It has received many hard names from its detractors. It has even been designated a tank, but it still holds its own in the mercantile marine, is practically universal, and does not appear to have a rival in the particular sphere in which it is so extensively used. The water-tube boiler is still in the future, so far as the tramp steamer is concerned, and it will take a good deal of successful application before it will supersede the well-tried favourite. In certain large and first-class lines, where the engineers are engaged in a fixed trade and grow old in service, the use of water tube boilers may be admissible; but they require delicate handling and a continuity of experience which, unfortunately, are not always obtainable in the general run of steamers in the mercantile marine. There the leaven



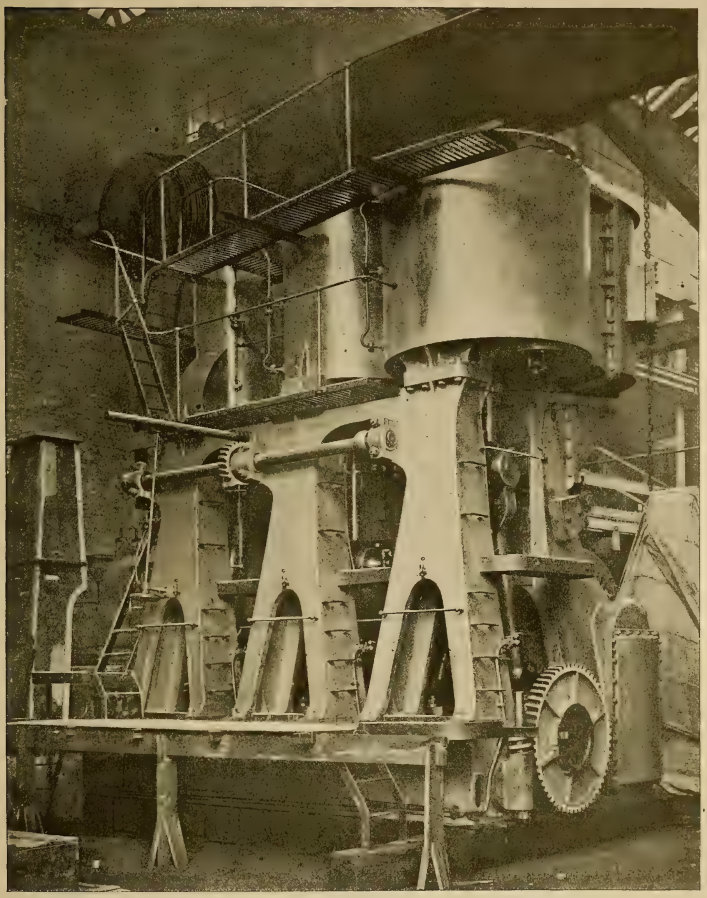
WATER-TUBE BOILERS BUILT IN 1874 FOR THE STEAMSHIP "PROPONTIS," BY THE ORIGINAL FIRM OF JOHN ELDER & CO., GLASGOW



THE ENGINE OF THE STEAMER "PROPONTIS," 1874

of the old saying that "there are more ships than parish churches" still tends frequently to changes in the engine room for small and inconsiderable reasons which are totally inconsistent with the successful management of the delicate organisation of improved water-tube boilers of the modern type.

For the above and many other obvious reasons the general use of a boiler with which a certain amount of liberties can be taken is a necessity. As one of the reasons may be cited the difficulty often found in inducing those in charge to make an intelligent use of the evaporator. The aggregation of factors in favour of the retention of the boiler of the present day cannot, therefore, be ignored by the general body of ship owners. They have to work against

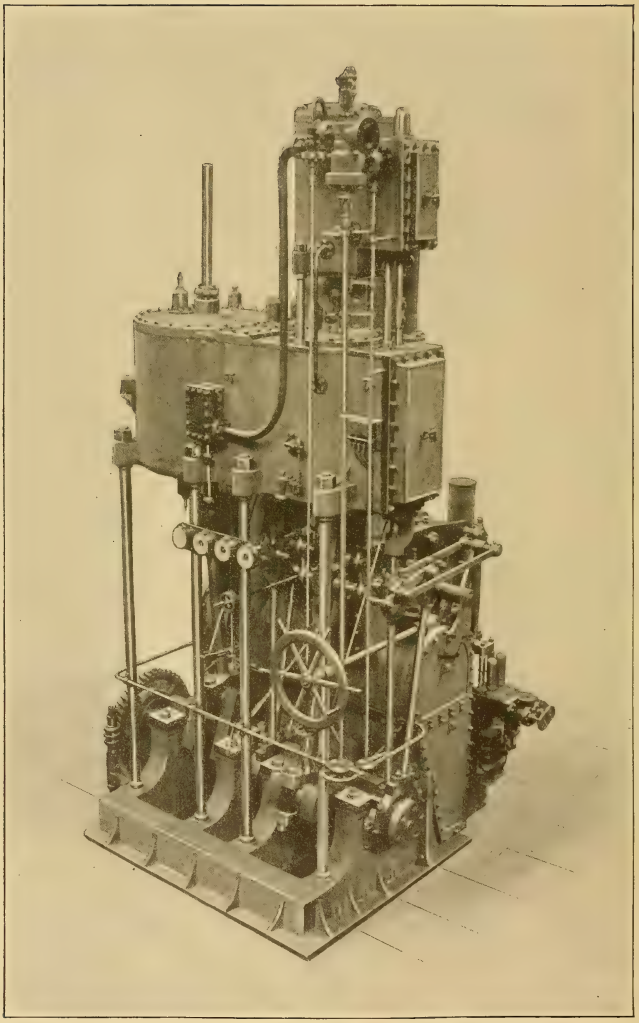


ANOTHER VIEW OF THE "PROPONTIS" ENGINE

ever increasing competition at home and abroad, are obliged to use what will give them reasonably economical results, both in first cost and upkeep, and at the same time protect themselves, as far as possible, from ignorant or incompetent men.

It is not to be understood from the foregoing that the water-tube boiler is in any way condemned or even disparaged. The fact is simply that it is considered too delicate for the rough handling to which it would, in all likelihood, be subjected, and that its proper sphere is in the regular lines indicated above and in the Navy, where its general use has been found to be successful.

The general introduction of the Siemens-Martin process for the manu-



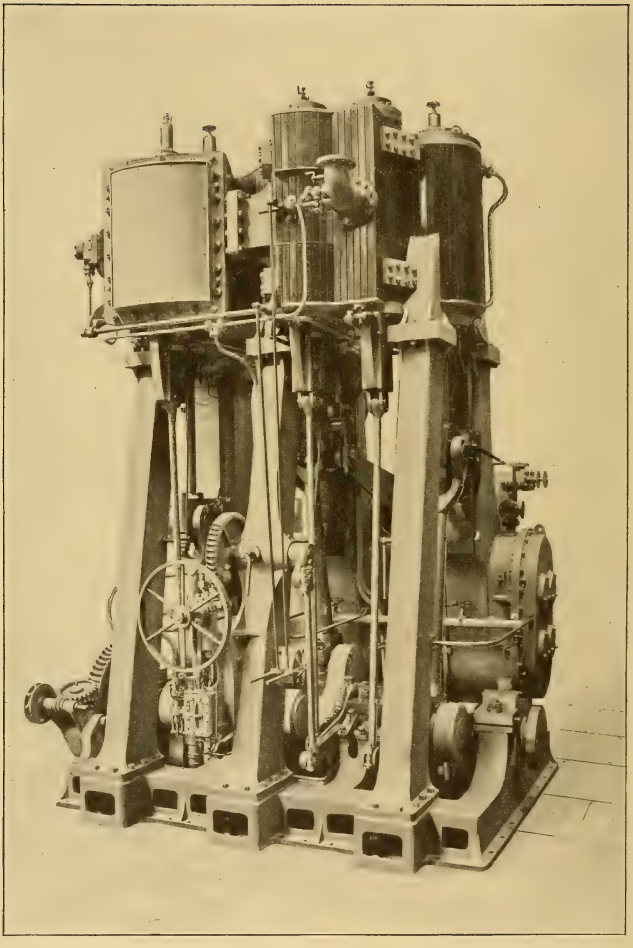
THE ENGINES OF THE "CLAREMONT," DESIGNED BY ALEXANDER TAYLOR, AND BUILT IN 1881 BY MESSRS. DOUGLAS & GRANT, KIRKCALDY, N. B.

facture of mild steel for ships and boilers, coupled with the strict and sensible rules formulated by Lloyds Register for its testing and manipulation, gave confidence to the engineering world generally, and this, combined with the inherent good qualities of the steel, certainly hastened its general adoption. Plates of five tons and upwards of this material are now in everyday use for boiler shells, and the strides made in this branch alone since 1881 may be shown from the fact that at the time mentioned no firm on the North-East Coast of England either could or would undertake to build a boiler for 150 pounds pressure. The order was, therefore, given to Messrs. Douglas & Grant, of Kirkaldy, who have thus the honour of being the makers of the first high-pressure Scotch boiler which was commercially successful. This was for the *Claremont*, Messrs. Fisher, Renwick & Co.'s first triple-expansion ship, launched in November, 1881.

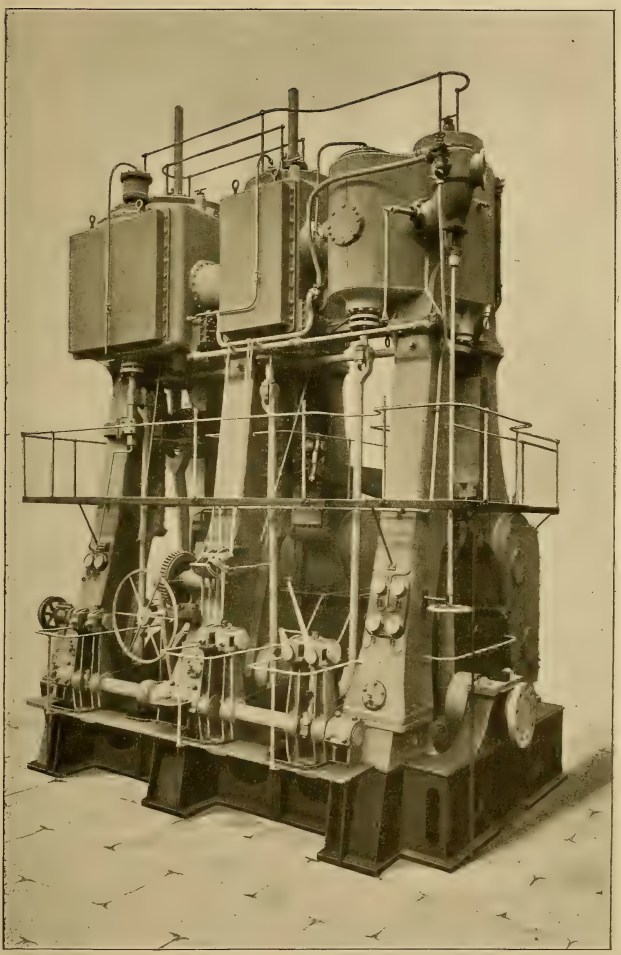
Considering the enormous number of boilers now made of mild steel, it has been a splendid justification for its general use to find how few failures have occurred, and where they have occurred, it may be added in justice to the material, they have been more frequently in manipulation than in manufacture. An instance of its fine quality, even in the early days, and which strengthened general confidence in it, may be noted. In 1882, when the main boiler of the steamer *Albertina* was being lifted on board, the sling broke, and it fell a distance of about 20 feet on to its seating, considerably bending the shell at the circumferential seam, but without fracturing the plate. The injured part, as a matter of precaution, was fitted with a strap, and the boiler did its work well until a year or two ago, when it was replaced. A curious coincidence here occurred. The sling of the new boiler broke under the same circumstances as in the case of the old one, but with an unfortunate loss of life. The injury, however, was of a character which could be easily made good, and the boiler is now in successful use. On the whole, steel boilers, after a long experience, are doing good work. They can be, and are, in the majority of cases kept free from corrosion, and the forecast that many would last for at least thirty years seems to be on a likely course of fulfilment.

When the triple engine was found to be a commercial success, a large number of old engines were converted, and the vessels were fitted with new boilers, while others were re-engined as well. In many of these cases ingenious devices were tried so that the altered or new engines should occupy the same, or only a slightly increased bed-plate length, relatively to those generally fitted. In altering the engines many firms superposed the third or high-pressure cylinder on the top of either the forward or after cylinder. One firm utilised the mid eccentric pit for the new engine, the three sets of valve gear being worked from two pairs of eccentrics only; while in the case of those who could afford the room, a third engine was attached complete at the forward end of the bed-plate. Messrs. Palmer, in the *James Joicey*, and others, fitted an interchangeable crankshaft with the crankpin of the centre engine, made with a coupling at each end to fit into a recess in the web.

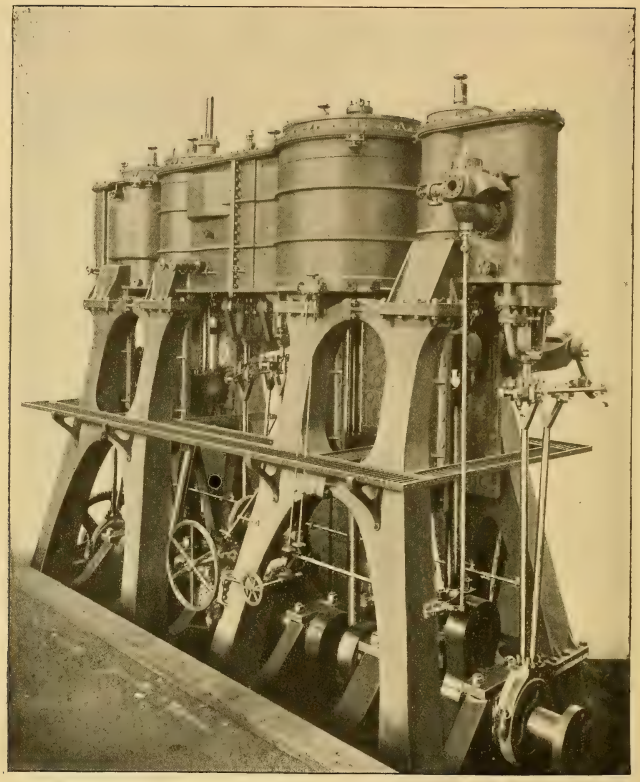
It was seen at quite an early stage of the tri-compounds that the three-crank engine, with cranks at equal angles, from its easy turning moments would be the most satisfactory, and its universal adoption in all new designs was the work of a very short time. At present, in new vessels where there is a superabundance of engine-room space, the valve gear has, as a general rule, returned to the old double-eccentric link motion. A notable exception to this, however, is to be seen in the large cargo boat engines of Messrs. Hawthorn, Leslie & Co., of Newcastle-on-Tyne, in which the valves are worked by a special single eccentric gear adapted by Mr. F. C. Marshall. These engines, indicating 3000 H. P., and working with a pressure of 160 pounds, have been fitted into twenty-one large cargo steamers. Unquestionably the most advanced type of



TRIPLE-EXPANSION ENGINES OF THE STEAMER "JAMES JOICEY." BUILT BY PALMER'S SHIPBUILDING AND IRON CO., LTD., JARROW-ON-TYNE



TRIPLE-EXPANSION ENGINES BUILT BY MESSRS. R. W. HAWTHORN, LESLIE & CO., LTD., NEWCASTLE-ON-TYNE. 3000 I. H. P. 160 LBS. PRESSURE



FOUR-CRANK, QUADRUPLE-EXPANSION ENGINES ON THE YARROW-SCHLICK-TWEEDY SYSTEM. BUILT BY MESSRS. WIGHAM RICHARDSON & CO., NEPTUNE WORKS, NEWCASTLE-ON-TYNE

multiple expansion is to be seen in the five-crank engine, first designed and introduced by the late Mr. Thomas Mudd, of West Hartlepool, and made by the Central Marine Engine Works. It is stated that engines of this type are propelling a vessel of 5800 tons dead weight at an average speed of nine knots on a daily consumption of 13½ tons of ordinary coal, this being at the rate of 1 pound per indicated horse-power per hour.

The average coal consumption was stated by Mr. F. C. Marshall, in a paper read before the Institute of Naval Architects in 1887, to have been 2.11 pounds per indicated horse-power per hour in 1872, and 1.828 pounds per indicated horse-power per hour in 1881, while to-day the ordinary cargo boat averages, for all purposes, 1.5 pounds per indicated horse-power per hour. This further economy is due, doubtless, to an aggregation of improvements, but firstly and principally to the small range of temperature due to the duplication of the cylinders. Whether the initial cost and upkeep due to this duplication

of parts will ultimately pay is a question for the future, and owners, who are, after all, the real arbiters in the question, will have to decide.

The average working pressure in 1881 was 77.4 pounds; but out of 179 sets of engines classed in Lloyds Register since July, 1899, 80 per cent. were above 160 pounds, 8 per cent. above 200 pounds, and none below 100 pounds. Appended is a table showing the percentages of pressures in 1879 and 1899.

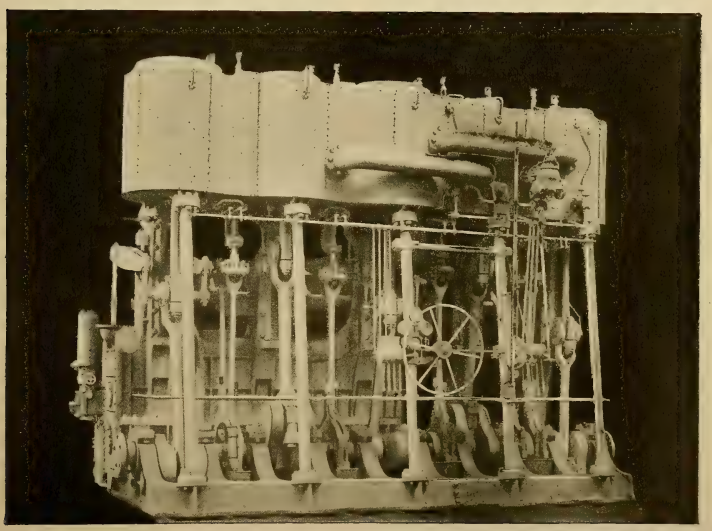
BOILER PRESSURE IN THE MERCANTILE MARINE IN TWENTY YEARS AS SHOWN IN LLOYDS REGISTER.

1879.						1899.
3.5 per cent.	Below 20 pounds.					
6.9	"	20 pounds	to	30 pounds.		
4.2	"	30	"	40	"	
3.3	"	40	"	50	"	
3.3	"	50	"	60	"	
32.5	"	60	"	70	"	0.5 per cent.
36.1	"	70	"	80	"	6.6 "
9.4	"	80	"	90	"	12.3 "
.9	"	90	"	100	"	4.2 "
		100	"	150	"	10.2 "
		150	"	165	"	45.2 "
		165	"	200	"	16.6 "
		200	"	and above		3.7

Five are recorded at 100 pounds, two at 120 pounds, and one at 150 pounds.

Over 5000 steamers are registered with a pressure above 100 pounds.

In the last twenty years the amount of machinery placed in cargo boats has multiplied to a very large extent, and the necessity has become evident for the engineer in charge and his assistants to be as qualified as the more advanced rules of the Board of Trade, regulating their initial training and examination, demands. At the commencement of the time referred to, and indeed for some years after, with the exception of steam reversing and steam turning gear, the staff on board had little to trouble them outside the main engines. Certainly steam was in occasional use for capstans and steering gear, but as the vessels were of small size compared to those now in vogue, the inclusion of such machinery was by no means universal. Forced draught and other modern elaborations were rarely seen. At the present day, however, we frequently find in a first-class tramp steamer, besides a larger set of engines than many an old P. & O. liner possessed, engines for reversing, for turning, for forced draught, for centrifugal pumps, feed pumps, auxiliary pumps, ash hoists, for electric lighting, etc.,



FIVE-CRANK ENGINES OF THE FAMOUS "INCH" LINE STEAMSHIPS "INCHMONA" AND "INCHKEITH," BUILT AT THE CENTRAL MARINE ENGINE WORKS, WEST HARTLEPOOL

many of which are in duplicate. To these add such trifles as evaporators, feed heaters, feed strainers, reducing valves, etc., and there can be small cause for wonder that the spare time of the engineers in charge has been much encroached upon.

Both electric lighting and refrigerating machinery, which latter represents another special phase of our change and improvement, have become so largely adopted that special rules for their fitting and subsequent examination have been formulated. At the present time over 285 vessels are recorded as fitted with refrigerating machinery, and their number is gradually growing. The work on these is so extensive and demands such special knowledge and attention that it is entrusted to a separate staff.

In two details of our engines we do not appear to have made satisfactory progress. We are still in almost an experimental stage with screw shafts and steam pipes, more especially with the former. The shortcomings of the screw shaft have been fully discussed and commented upon in many places; still it cannot be too often emphasised that the fact of their failing is not without reasonable cause, and that some alteration or amendment is required either in design or construction, or both. Two things, however, have always appeared inexplicable,—first, that the shaft should be the only piece of machinery in the ship supposed to be capable of running with water alone; and, secondly, that when one form of shaft has failed (sometimes several times) in the same vessel, an alteration in form or design has not been adopted, but the old, certain error is repeated again and again.

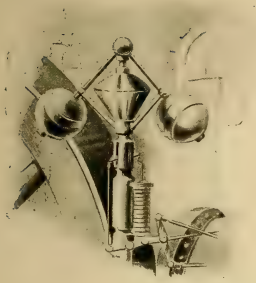
With regard to steam pipes, the slow progress apparently being made in the more general use of the expansion gland is very disappointing. It is practically a universal joint, is easily kept in order, and it seemed certain that it would come into constant use when the trouble experienced by pipes breaking at the flanges through stress had been thoroughly appreciated. This, however, is not so. Copper pipes with bends only to take up expansion are still common, the custom being to make these as long as possible so as to minimise the stresses on the ends. The use of the gland with iron or steel pipes is imperative, and it is a matter for astonishment that this material has made such slow progress in general favour, in view of the fact of its unqualified success in the earlier triples.

The machinery of cargo boats, especially since the practical abolition of the masts, has become of paramount importance. It may not, therefore, be out of place to predict a time when the master will also act as chief engineer. A step in this direction might be taken by allowing engineers to pass an examination and receive a certificate for proficiency in navigation in the same way that masters and mates are now enabled to pass on in steam engineering.

Speaking generally of the advance in the last twenty years, it appears that we have replaced iron by steel in boiler manufacture, adopted multiple-expansion engines, increased the working pressure, reduced the coal consumption, improved the machinery used in the manufacture of our engines and boilers, —especially the latter,—practically eliminated corrosion in boilers and added largely to the responsibilities and duties of those in charge.

TACHOMETRY

By Professor J. A. Fleming, D. Sc., F. R. S.



AMONGST the minor operations which the practical engineer has to perform, one of the most common is that of determining the speed of rotation of a wheel or shaft. We generally employ a prime motor, whether steam, gas, or oil-engine, to produce rotation in some form, and with the exception of certain appliances, such as steam pumps, the reciprocating movement of the piston is first changed by a crank into the rotational motion of a fly-wheel and is thence transmitted by belt, rope, or gearing to some other wheels or shafting. The necessity, therefore, frequently arises for finding the mean angular velocity of a shaft or its revolutions per minute, and this is done by means of instruments called tachometers.

The simplest device for this purpose is a counter, which is a little instrument held in the hand or fixed to the machine, consisting of a box containing a collection of intergeared wheels, on the edge of each of which are engraved the nine digits and zero. These numbers show up through little windows, and the wheels are so connected that when the first wheel has completed a revolution and is in process of passing from the position in which it shows up a 9 to the position in which it exposes a 0 to view, it pushes forward the next wheel from 0 to 1, and so on. These wheels are called the unit, ten, hundred and thousand wheels. The unit wheel is moved round either by a ratchet and pawl, or else its shaft projects out from the box and is provided with a sharp, square centre which can be pushed into the centre punch hole in the end of any rotating shaft, and so, by friction, turn the counter wheels. To use the counter, the observer takes his watch in one hand and the counter in the other, and having previously read the counter or set it to read 0 0 0 0, he holds its square centre close to the shaft centre, and then as the second hand of the watch begins a minute he pushes the centre home and lets the counter run. After one complete minute the counter is pulled away and read again. This should be repeated two or three times and the mean value taken.

A convenient form of speed counter is one supplied by Messrs. Berend & Co., of London, which combines in itself a counter and a watch running for ten minutes, and having only a second hand. The act of pushing the counter home against the shaft starts the watch hand, and the act of pulling it away stops the watch. The observer thus has only to hold the counter against the shaft for any observed time, and on pulling it away, he will find that the counter has registered the revolutions of the shaft in that time.

An instrument of this kind tells very accurately the total number of revolutions made by a shaft in any time, say, in one minute, but it does not tell whether the revolutions per second are uniform. The speed or angular velocity may be fluctuating considerably and yet the mean speed or revolutions per minute may be tolerably constant. Instruments have accordingly been devised, the purpose of which is to show the speed or angular velocity of a shaft at any instant and to exhibit fluctuations

in that speed. These instruments are generally denominated tachometers, as opposed to mere revolution counters.

In the majority of cases these tachometers consist of some form of small Watt governor, the outward motion of the balls or weights produced by the centrifugal action being resisted by a spring and the displacements being recorded by an index hand moving over a dial. It cannot be said that this type of tachometer is very satisfactory or accurate. The governor tachometer has the fault of all centrifugal governors, and it acts *after* the event; in other words, it lags behind in its indications. The mechanism, consisting, as it does, of parts having inertia and elasticity, possesses a natural time period of vibration of its own. Hence, if there be cyclical variations of speed in the shaft to which the tachometer is attached which either agree with or are harmonics of the natural time period of the tachometer mechanism, great oscillations will be set up in the tachometer needle which do not correspond to real variations of angular velocity in the driving shaft. Therefore, although useful just to show whether a wheel or shaft is rotating at about a proper speed, engineers do not generally give very much credit for accuracy to the readings of a governor tachometer.

Another and far better form is one which has been in use for many years in the dynamo room of the Pender Electrical Laboratory at University College, London. This may be called a hydraulic speed indicator. It consists of a small, circular, centrifugal pump, which may be constructed by enclosing in a brass box a brass four-bladed fan, the blades having their planes parallel to the fan shaft. The fan blades very nearly touch the inner side of the cylindrical brass box. The fan shaft is led out of the box through glands which are packed watertight against slight pressure.

Two pipes lead to this box, one entering near the shaft axis and one on the outer wall of the containing box. The former is connected to a reservoir of fluid which may be water, and the latter pipe is connected to a tall, vertical glass pressure pipe. The shaft of the fan is made to revolve by gearing it in any good manner to the wheel or shaft of which the angular velocity is to be recorded. When the fan revolves, it pumps the fluid from the reservoir and forces it up the standpipe a certain height, viz., until the head of the liquid in the standpipe just balances the so-called centrifugal force of the water at the extremities of the fan blades. Since this latter is a measure of the square of the angular velocity of the fan blades, it follows that the height of the water in the standpipe is proportional to the square of the angular velocity of the shaft

We may, therefore, put a paper scale behind the standpipe and once for all graduate it in divisions corresponding to various ascertained speeds of the shaft of the pump. It will be clear that these heights are independent of the nature and, therefore, of the density of the fluid used, and, therefore, also of its temperature. No matter what liquid is used, whether water, oil, or mercury, corresponding to a certain speed of rotation of the pump shaft, there is a definite height to which the liquid will rise in the glass standpipe when equilibrium is established. The smallest variation in this speed shows itself in a change of height of the liquid. Moreover, the greater the speed, the greater will be the actual variation in height in the column of liquid corresponding to a given percentage variation of speed.

One great advantage of this arrangement is that the glass gauge tube need not be near the pump. The pressure can be transmitted any distance through a metal pipe, and several gauge glasses may be served off one pipe. In the Pender laboratory one of these hydraulic speed indicators is attached to each alternator, and pressure pipes with scales attached, marked in revolutions per minute, are placed both in the dynamo room and in a transformer testing room some distance away. The alternators are driven by continuous-current motors, and the speed of these latter can be regulated by field resistances

from the transformer testing room. It is possible to control the speed of the alternators to within one-quarter of one per cent. by means of this hydraulic speed indicator.

In place of the vertical gauge glass it is possible to employ a delicate Bourdon pressure gauge, which can be graduated to indicate speed directly. It is a matter of surprise that this very convenient method of indicating at a distance the exact speed of a shaft has not been employed in electric lighting stations. It is quite possible to attach the hydraulic pump to the shaft of each dynamo or alternator, and to have the pressure gauges, or indicating columns, side by side on the switchboard at any distance, so that the attendant can see at a glance the exact speed of each machine.

We pass on, then, to another point, —the detection and measurement of inequality in the angular velocity of a wheel or shaft during each revolution. It is a familiar fact that in the case of gas-engines or oil-engines with a single cylinder and working with an Otto cycle, the rotational inequality is very marked. It exists also in steam-engines with one and two cylinders, but is less pronounced in the case of engines with three or more cylinders, each working on its own crank.

One method which may be employed to detect it is called the stroboscopic disk method. A disk of cardboard is divided into concentric rings, and each ring is divided up into equal spaces, alternate spaces being made black. The number of these "teeth" is made to vary from ring to ring. This disk is attached to the shaft of which the rotational inequality is to be tested. A tuning-fork is then provided, which is maintained in vibration automatically by an electromagnet, and to its prongs are affixed two little vanes of aluminium having slits in them. These vanes overlap in such a manner that when the tuning-fork vibrates, the little window formed by the slits is opened and closed. Hence, if the fork vibrates, say, one hundred times a second, the opening is closed and opened at this rate.

Suppose, then, that the above mentioned disk has on it five concentric circles, the interspaces being divided up into 52, 50, 48 and 46 equal black and white "teeth"; and suppose that it is attached to a shaft making about 120 revolutions per minute! On looking through the slits in the tuning-fork vanes we shall see three of the four rings of teeth rotating slowly, but one of them nearly stationary. The one which is stationary will be that one which has 50 teeth, because if the disk rotates twice a second it is evident that in each hundredth of a second a black "tooth" will move exactly into the place occupied by its next neighbour. If, then, the rotation of the shaft is non-uniform, we shall notice that no one of the rings of "teeth" appears exactly stationary, but that one of them oscillates to and fro, or moves forward with slight jumps or leaps, something like the motion of a rowing boat.

This stroboscopic method is a very delicate test for the existence of non-uniformity of angular velocity, but it does not enable us to evaluate it numerically. If, however, the inequality is not too small, it may be measured in the following manner:—A brass or iron disk is attached to the shaft, the disk having a square-sectioned groove on the edge, of sufficient width to just take a strip of the paper tape used in Morse telegraphy. This tape is supplied in flat rolls. The tape roll must be fixed in a centre so that the tape can pay off easily, and the tape is just laid over the grooved disk. A jockey pulley, having a leather edge, is arranged so that, when required, it can be pressed against the tape and cause it to run with the same velocity as the periphery of the grooved disk.

An electrically-driven tuning-fork has a pencil fixed to its prong and is so held that this pencil describes a wavy line on the paper tape when the latter runs with the wheel and the fork vibrates. Hence, if the fork makes, say, 100 vibrations per second, it will draw on the paper tape a wavy line, the wave length of which represents a time interval of one-hundredth of a second. Accordingly, if the disk moves with unequal velocity

during a revolution the wave length of the wavy line will be longer in some places than others. By carefully measuring the wave length in different places on the tape corresponding to one complete revolution of the disk, we can obtain lengths which represent the angular velocity of the disk at different instants during the revolution. These can be set up as ordinates on a horizontal base line representing the time of one complete revolution, and they define a curve of angular velocity, or, as it is usually called, "turning moment."

This method is easily applied if the velocity of the shaft is from 50 to 200 revolutions per minute, and if the tuning-fork makes $\frac{1}{2}$ 100 vibrations per second we can so proportion the size of the disk that the wave lengths of its line described upon the paper are about an inch in length. In this case, it is not difficult to ascertain whether there is a variation of angular velocity of as much as 2 per cent. within the cycle of one revolution of the shaft.

Absolute uniformity of angular velocity of rotation is an important matter in connection with the parallel working of large alternators in electric stations. If alternators having a large number of field poles are worked in parallel, then it is obvious that a very small absolute displacement of the armatures of two alternators relatively to each other will make a much greater relative phase shift in their electromotive forces. If, therefore, there is a variation of speed in the armature during the revolution, conditions will arise under which large, wasteful currents pass backwards and forwards between the alternators, and give rise to difficulties in getting the machines into parallel and keeping them there.

THE FUTURE POWER PROBLEM

By T. C. Mendenhall

DURING the nineteenth century for the first time in the history of the world men have made extensive use of sources of energy other than their own bodies. The human animal began to differentiate himself from others by the acquisition of such accomplishments as throwing a stone or wielding a club, and after many centuries of evolution he at last reached a state not materially different from that in which a few tribes of savages are still found. Although immeasurably superior to other animals in the way in which he utilised his available energy, in common with them his supply was limited, during this long period, to that which his own muscles were capable of furnishing.

The inevitable domination of the strong over the weak must have set in at an early date, and the establishment, at that time, of human slavery must be regarded as a blessing to the race as a whole, because it enabled those who, by reason of physical, intellectual or moral superiority, were masters, to direct a power vastly greater than that of their own bodies; and thus men, acting in obedience to authority, easily accomplished what man, individually, would hardly have ventured even to attempt. There are still in existence many evidences of the successful execution at this early period of engineering operations of great magnitude and importance in which human muscle was the only available, or at least the principal, source of energy, and the practical ownership of this supply of power was necessary to the success of work by which the whole race was lifted a little out of the domain of mere brute force.

The utilisation of the muscular power of other men must have suggested, at a very early time, the possibility of controlling and directing the more powerful muscles of the lower animals. No small amount of intelligence, skill, and cunning is necessary to the accomplishment of this end, and the training of the horse and ox for power purposes marked a distinct advance in the direction of modern civilisation.

A horse will do the work of six or seven men; his food is coarser and cheaper than that required by man; his years of useful activity are fewer, but he reaches maturity sooner, and when once thoroughly "broken," he is more easily controlled and directed than a man. Owing to these qualities the horse, as a source of power, will long continue to be important, notwithstanding his relatively low efficiency when considered simply as a machine. Absolutely, the output of real "horse-power" is probably greater to-day than ever before, but relatively it has long been small, and is constantly and rapidly growing smaller.

At the beginning of the nineteenth century the work of the world was very largely, indeed, almost entirely, done by muscle, as it had been from the beginning of human industry. At the end of that century the contribution of human muscle to the total power supply is relatively very small. It is difficult to estimate its quantity, but it is certainly not more than 10 per cent. of the whole, and is much more likely to be less than 5 per cent. The ease and accuracy with which muscular energy may be directed give it a value often many thousands of times greater than that of its equivalent in mere work, as meas-

ured by ordinary resistances overcome, and nothing can ever take its place, for it is the only energy immediately controlled by human intellect. "Made by hand" is usually, and properly, accepted as a certificate of superior excellence, for the most perfect machines are still inferior to human muscle directed by intelligence. Indeed, they must always be subordinate to that by which they are themselves created.

The shifting of a large share of the burden of work from the shoulders of men to the horse and the ox was a thing of prime importance, but, mechanically and economically, it is of much less moment than the introduction of the so-called physical forces into the workshop. For a long time, and until a comparatively recent period, the energy thus made available was either that due to gravitational attraction or to the motion of a mass of matter. The latter is exemplified in the work done by air in motion, or wind power, while water power is due to gravitational energy, although both forms ultimately involve heat.

As the first, and for a long time the only, non-muscular sources of power, water and wind have played a most important part in the history of civilisation. By the power of the wind geographical discovery and exploration became possible; nearly all parts of the world became known to Europeans, and much of it was colonised by them; both international commerce and international war were enormously facilitated; by an interchange of products, material and intellectual, increased production was encouraged; a wide dissemination of religions took place; and, indeed, it was only through the utilisation of wind power that man got a lasting hold upon the inhabitable earth. It is hardly to be imagined that human muscle alone could ever have brought this about.

It is only as applied to the propelling of ships at sea that wind power has been, up to this time, of any special consequence. Its use in connection with stationary machinery is a thing of modern times, and its importance will be considered later, but the remarkable simplicity of the means necessary to its employment in driving ships makes it almost certain that this type of non-muscular energy was the earliest of which man availed himself.

The recognition and development of the power of falling water implies no small degree of engineering instinct and technical skill, yet it occurred in an antiquity so remote that we shall never be able to do honour to the first great hydraulic engineer, the inventor of the water-wheel. With the introduction of water power began, although at first in a very small way, the use of machinery as a substitute for manual skill. As long as the workman furnished all of the power demanded by his handicraft, the machinery he employed was limited, often to his own fingers and hands, supplemented by a few tools of the simplest kind.

Curiously, the word "manufacturing" really means "making by hand," which is just what it does not mean in its modern acceptation, and in this modern sense manufacturing,—"making things by machinery,"—practically began with the introduction of water power, by which machinery could be run. Instead of pounding the corn or turning the millstone, men occupied themselves with the far more agreeable task of seeing that the mill was supplied with material; instead of making the wheels go round, they watched them go, and saw that they went properly. This was the first great step towards emancipation from the slavery of that unintelligent toil in which man differs from the beasts of the field only by being inferior to them.

Up to the beginning of the nineteenth century no other sources of power than these three,—muscle, air in motion, and water,—were extensively employed. The only opportunity for great expansion in the world's output of work was in the greater use of water and wind. But while the total energy embodied in these two elements was enormous, its utilisation was subject to such serious limitations as to time, place, rate of supply, and others, that power development was slow, coming, when it came

at all, as a result, and not as a cause, of the steady enlargement of human enterprise. Wind power was used only as a last resort where nothing else was available. Water power could be used only where it existed, and for this reason it sometimes directed the course of exploration and colonisation; but agricultural resources and possibilities were always considered as vastly more important. For these reasons those arts and industries dependent upon the use of machinery or upon rapidity or cheapness of transportation made comparatively little progress during several centuries preceding the nineteenth, being, in the nature and quality of their products, not very different from what they were at the beginning of the sixteenth, and, indeed, a thousand years had brought no remarkable extension in their operations or innovation in their methods.

The great revolution in industrial processes and operations which constitutes the glory of the nineteenth century began with the recognition of the value of heat energy and the possibility of transforming it into useful forms of power. More than a thousand years ago this transformation was attempted, with little real success, however, and with less understanding of the nature and meaning of the operation. It was only when this was revealed by the genius of Watt and Rumford that the new era actually set in. They, first of all, distinctly comprehended the interrelation of heat and mechanical energy, —their equivalence and capacity for transformation. They showed that any source of heat was a source of power, and the combustion of fuel began at once to supersede or supplement the use of muscle, water or wind in the work of the world.

The new power possessed so many advantages over the old, especially in availability and constancy, that its development was rapid, even in the beginning. The limitations to the current supply of combustible material in the form of wood would soon have checked this development, but, happily, an enormous, apparently inexhaustible, stock of fuel in the convenient form of coal was at hand, and with continued improvement in the construction and efficiency of the engine by means of which the transformation of heat into power is accomplished, the combustion of fuel and the transmutation of the heat produced into various forms of mechanical energy has gone on for a hundred years, increasing in magnitude at a rate which is almost bewildering, creating conditions of which few people grasp the full significance, and affecting the entire human race in its relation to its environment more profoundly than any other event in its history.

The nature of the changes thus wrought is well known among intelligent people, but their extent is so little appreciated that it will be useful to consider, briefly, that phase of the subject, and especially to endeavour to present it in such a way as to emphasise the purely power aspect of the question.

Everybody has a more or less correct idea of the enormous development of steam navigation and railway systems and of the cheapening of transportation brought about by it; of the phenomenal growth and widespread distribution of manufacturing establishments; of the generation and use of electricity as a convenient means of transmitting energy; and of many other things characteristic of the industrial revolution through which we are passing.

It is instructive, however, to reduce it all to the daily combustion of a certain, rapidly increasing number of pounds of coal, for these may be easily converted into their muscle equivalent. And since by far the greater part of the coal output goes directly or indirectly into the production of power, no attempt will be made to separate from the whole that which is used purely for heating purposes, and, indeed, the very general consideration of the subject to which this discussion must be restricted does not require such separation. Furthermore, for convenience in understanding numerical relations, it may be assumed that the combustion of one pound of coal under the favourable conditions of modern practice produces

available energy equal to the work of one horse for one hour, and that a horse-power is equal to the power of seven men.

The total quantity of coal taken in any given year from the mines of the whole world cannot be very accurately ascertained, but from the best available information it may be assumed to have been about 700,000,000 tons of 2000 pounds each for the year 1900, the last of the nineteenth century. Using the relations assumed above, it is found that this represents in energy the equivalent of 9,800,000,000,000 hours of work for one man, and allowing ten hours to each day and three hundred working days to the year, this is found to be equal to the work of 3000 millions of men during one year. This is about double the entire population of the globe, and it follows that the utilisation of the energy of combustion is equivalent to an increase of the working capacity of this population to the extent of an addition of two able-bodied men for every man, woman, and child; and practically it amounts to much more than this, for these additional 3000 million stalwart labourers make no demands upon the food products of the world; they need no clothing, no matter what the zone of their employment, and in faithfulness, loyalty, general docility and ease of management they are beyond compare.

A very large share of the population of the earth still do not take advantage of non-muscular uses of power, and the transformation is confined to civilised nations. Its full significance can be better understood by studying its influence upon one of these, and especially upon the United States,—itself a creation of the nineteenth century. The output of the coal mines of the United States has increased with unparalleled rapidity during the past twenty-five years, and for the year 1900 it may be assumed to be about 250 millions of tons. Converting this into human labour, as above, it is found to be equivalent to the work of 1200 millions of men for one year. This is about sixteen times the entire population of the country, and it means, therefore, that the energy thus put at disposal is equal to that of sixteen labourers for every inhabitant. Thus, in the average, every man, woman, and child has sixteen able-bodied slaves working for him ten hours a day and three hundred days in a year.

In a somewhat less degree the same is true of the whole English-speaking population of the globe. The mines of Great Britain and the United States furnish about three-quarters of the entire annual output of coal, and both nations jointly control three-quarters of the power of the world, for which reason alone they are easily the controlling factors in the disposition of its affairs.

Perhaps the most serious aspect of the power problem at present is the rapidly increasing annual draught upon available sources of supply. It may be said of the world's energy account that up to the beginning of the nineteenth century its expenditures were equal to its annual product; there was no surplus or deficit. With the new era, however, began the draught upon the enormous accumulations of a remote age, the current supply being no longer adequate. In the very nature of things this reserve of stored power is limited, and must, sooner or later, be exhausted. In the United States and Great Britain there has been a surprising increase in the quantity of coal taken from the mines during the past quarter of a century, and this increase has been much greater in the former country than in the latter, corresponding to its more rapidly developing industrial interests. In the United States the coal output of 1900 was very nearly seven times that of 1870; in Great Britain it has only about doubled in that time, and is now a little less than that of the United States. All other coal producing countries bear similar testimony to the wonderful increase in the use of power.

The amazing growth of steam power at sea is seen in contrasting such vessels as the Cunard liner *Britannia* of 1840, whose engines were then famous for their 750 horse-power, with the *Deutschland* of current type, whose energy

capacity is nearly fifty times as great. Such a ship as this gives some idea of the full meaning of the use of heat energy instead of muscle, for if the 33,000 horse-power of its engines were converted into man-power, remembering that in continuous effort, like that assumed, men cannot work more than eight hours out of the twenty-four, about 700,000 men would be required to drive the vessel as now driven by coal combustion. The *Britannia* consumed nearly five pounds of coal for every horse-power-hour; the *Deutschland* consumes only one-third or one-fourth as much, but her power demands are so much greater that her coal consumption is, perhaps, fifteen times that of the earlier ship; besides, there are many of her type, in 1900, for one *Britannia*, in 1840. The transportation of goods by rail affords an illustration of the expansion of power consumption equally startling, and the same is true of manufacturing and other industrial operations.

Up to the present time, with comparatively insignificant exceptions, all of these draughts upon the energy reserve of the world have been cashed at one bank, and that is the coal bank. The combustion of fuel, in one form or another, has kept the wheels turning. Against a large and ever growing demand for fuel there is a fixed and limited supply. How soon the accumulated stock will be exhausted (never again to be restored) it is impossible to say; but it is not likely that any very extensive supplies of coal, oil, or gas not now known to exist will ever be accessible. However this may be, the practical elimination of fuel as a source of energy in the not very distant future must be regarded as a certainty, and for some years thoughtful people have been looking about for a possible substitute.

The introduction of new sources of power will come gradually, and no one can now tell by what agent or prime motor the work of the world will be done one hundred or two hundred years hence. Fortunately, it is easy to find stores of energy vastly greater in amount than that upon which the nineteenth century fed, and grew, and flourished. Their availability must determine their usefulness, and their development is already the subject of much experimental research.

The application of electricity to the transmission and to the storage of energy has quite altered the power problem, and it has been especially important in bringing about a revival of interest in those long known sources,—the earliest of the non-muscular,—water power and wind power. When it becomes possible to store energy cheaply and to hold it without loss, wind power will assume a high rank. The total quantity of it is enormous; in a sense it is "current supply," and not a draught upon a limited stock; it is more generally distributed than water power, compared to which it possesses many advantages.

Just now much attention is given to the development of water power, from which hitherto existing restrictions as to use in the immediate neighbourhood of the waterfall have been removed in large measure by electric transmission. There is every reason to believe that in the near future economical transmission through hundreds of miles of wire will be possible, and in this way water power may shortly become, as, indeed it already is in some degree, an active competitor of fuel.

But even if this be accomplished, it is tolerably certain that the total energy of falling water will be inadequate to the demands which must be met. The most famous water power of the world is Niagara Falls, over which about 18,000,000 of cubic feet of water pass every minute, the equivalent horse-power being about 5,000,000. Remembering that this goes on day and night, it is easy to see that this is equal to about 80,000,000 of men working ten hours each day, a number greater than the entire population of the United States. Of course, it is very unlikely that any very large proportion of this power will ever be actually made available; at present about 2 per cent. of it is being used, but if it were all consumed it would be equal to only about one-twelfth

of the present power supply from the coal mines of the United States alone. Almost invariably water power is subject to meteorological conditions to such an extent that it is, in a way, even more unsteady and unreliable than wind, and some system of storage, more perfect than any now in use, will be absolutely essential to the development of its highest efficiency.

It is almost certain, therefore, that it will be necessary to turn to storehouses of energy not hitherto made use of, or, if at all, only in a very limited and tentative way. One of the first of these to be thought of, because oftenest talked about and already tried in a small way, is the heat received directly from the sun. Many inventors have been sanguine of success along this line, but thus far little has been accomplished. The amount of radiant energy reaching the earth from the sun is enormously large, approximating a million times the present product of fuel combustion, and it may be expected to continue without sensible change for a practically indefinite period. But in availability it ranks very low, being especially affected by geographical localisation and meteorological conditions. It is greatly diffused, and even with ideally perfect collectors only a very small part of the total amount could ever be converted into work. Under present conditions it is not worth considering as a possible source of power.

Much more promising is the great tidal movement of the ocean, a species of water power, although originating in a source very different from that of the ordinary waterfall. For hundreds of years occasional use of tidal power has been made, but with the prospect of the exhaustion of fuel supplies, the possibility of electric power transmission, and especially in view of the rapidly growing demand, its use in a large way must, before long, be seriously considered.

It is interesting to note that while the energy of ordinary water power is due ultimately to the heat of the sun, by which water is continually carried from a lower to a higher level, that of the tidal wave is dependent upon the rotation of the earth upon its axis. The earth may be regarded, mechanically, as a huge fly-wheel of enormous mass, its mean density being not greatly less than that of iron, which, in some way or other, has been set spinning about its axis and is thus a storehouse of energy, the amount of which is practically inconceivable. The effect of drawing upon this supply would be to lessen the speed of rotation if there were no compensating influences, that is, to increase the length of the day. Of the immensity of this source of power it is almost impossible to form an adequate conception. If it could be tapped successfully it might be drawn upon indefinitely, and every demand might be satisfied without serious disturbance of the solar system.

Great, also, beyond our power of calculation is the stored energy of the interior heat of the earth, and some not entirely unsuccessful attempts to utilise this have already been made. From a short distance below the surface the temperature increases downwards at an average rate which indicates that at a depth of fifty miles it is not less than 5000° Fahr., and there is abundant reason for believing that the earth is an intensely hot body with only a thin layer of poorly conducting, cold surface matter. These are the essential conditions of a heat engine of enormous capacity, and as in many parts of the world comparatively high temperatures are found very near the surface, while in all parts considerable ranges are possible within reasonable differences of level, the interior heat of the earth, which has an origin more remote in time than the sun, or its own axial rotation is worthy of most serious consideration as a possible and reasonable source of power. Its importance will be greatly enhanced when we are able to transform heat energy directly into electricity on a large scale and with economy, avoiding the great waste which necessarily accompanies the use of the steam-engine; and this must soon come about.

The power by which, for the most part, the work of the world will be done

during the next few centuries must come, it is believed, from one or more of the sources here considered. They are none of them fanciful; all are, even in the present state of science and art, within reach, and in capacity they are sufficient to satisfy any conceivable future demand. The abandonment of fuel as the chief source of energy is sure to come; its use is accompanied by many well recognised and harmful disadvantages, and it is not improbable that the time will come when men will look upon the era of coal much as we now look upon the Stone Age of our ancestors.

THE ECONOMICAL SPEED OF SHIPS

By E. H. Tennyson-D'Eyncourt, M. Inst. N. A.

The wish has been frequently expressed that engineers would give the results of their experience derived from the actual performance of vessels on progressive trials, and the methods adopted in estimating the power necessary for driving ships at given speeds. Mr. Tennyson-D'Eyncourt, therefore, endeavoured to gather the data from a large number of trials of ships of different forms and to derive from them certain broad, practical rules, and these he presented a short time ago before the Institution of Naval Architects in the following paper.—THE EDITOR.

IT has, perhaps, been too common a practice in fixing the speed for a vessel, and in estimating the necessary indicated horse-power for that speed, to overlook the question of what speed is appropriate to the form of vessel under consideration, and to go upon the broad basis of allowing plenty of margin of horse-power, with the result that often too high a speed has been aimed at and too much power has been allowed. As a necessary consequence, the weight and cost of the excess have been a continual burden upon the earning capacity of the ship. This was, perhaps, very well when competition was not so keen; but nowadays, when cost has to be cut down to a minimum in every direction, not only by the shipbuilder, but also by the shipowner, the question of giving a ship enough, and not too much, power and speed has become one of first importance.

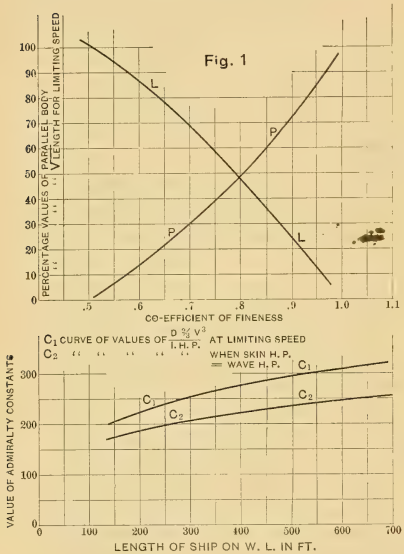
It is necessary to bear in mind the fact that every ship has an appropriate limit of speed, beyond which it is most uneconomical to attempt to drive her; or, in other words, any increase of speed beyond this limit requires an undue increase of power. It has, therefore, been my object to arrive at a method of defining this limiting speed for ships of different sizes and different forms.

To attempt to arrive at a general solution to meet all cases is an impossibility; but a fair approximation to the suitable power and speed may be arrived at by a consideration of the general principles governing the relation between the dimensions and form of ships on the one hand, and the appropriate speed and power on the other.

To obtain accurate values it is necessary to consider each case individually upon its own merits; to have the exact form of the under-water body, and a record of the performance of a similar ship, or of model experiments.

In analysing the trial results which the writer has had at his disposal, he has not attempted to divide the indicated horse-power absorbed into all the heads, which, in making an exhaustive analysis, would, perhaps, be necessary; but for the sake of ease in comparing the performances of different vessels, he

has always assumed the effective horse-power to be half the indicated horse-power. This is a somewhat crude method, perhaps, but as good as any other, where so many unknown, or at least doubtful, quantities are involved. This is also a fair average value to assume for the propulsive coefficient, with modern triple or quadruple-expansion



machinery and suitable propellers, at the higher speeds considered. Having, therefore, made this assumption, the writer has proceeded to calculate the horse-power absorbed by skin friction on the basis given by the late Mr. Froude, and now universally adopted; and the difference, after deducting the skin horse-power from the effective horse-power at any speed, gives the power necessary to overcome the so-called residuary resistance, which, at the higher speeds, is principally caused by wave making. For brevity's sake this may be termed the wave horse-power.

The different values of the wave horse-power obtained by this method for similar ships, and in some cases for sister ships, show up the variations in the value of the propulsive coefficient of propeller efficiency actually occurring in practice; but the merit of the method lies in the fact that it gives a definite comparison between the performances of different ships. The naval architect must make allowance for the efficiency of machinery as experience dictates. Having obtained curves in the manner indicated for many ships of varying dimensions, forms, and degrees of fineness, the writer has been able to deduce the general results shown in the table below. This gives the coefficient of fineness and the amount of parallel body which may be associated with that coefficient, and the corresponding limiting economical speed, expressed as a percentage of the square root of the length of the ship in feet on the water-line.

Coefficient of Fineness.	Parallel Body Percentage of Total Length of Ship on W. L.	Limiting Economical Speed as Percentage of $\sqrt{L}$, in Feet.
0.5	0	100
0.6	14	86
0.7	30	68
0.8	49	48

The upper one of the diagrams on this page shows these values in curves PP and LL. The former gives the appropriate length of parallel body, which is equivalent to giving the combined lengths of entrance and run; and it will be seen that the percentage values of $\sqrt{L}$ for the limiting economical speed are practically the same as the percentage values of the combined length of entrance and run. This agrees with the value which has been given for vessels with no parallel body, but gives a smaller economical speed for vessels with parallel body, the previous rule having been that the economical speed is equal to the square root of the sum of the lengths of entrance and run, and it seems to show that a penalty must be paid for introducing parallel body.

Taking actual trial results, the writer finds that the indicated horse-power at the limiting speed, as defined above, is varying as the fourth power of the speed, and varies, in increasing ratio, till at about 12 per cent. above the limiting speed it is varying as the seventh

power of the speed; whilst the wave horse-power varies as v^7 at the limiting speed, and as v^{10}, or sometimes as a higher power of v, at 12 per cent. above the limiting speed; and that at this point, viz., about 12 per cent. above the limiting speed, the wave horse-power is approximately equal to the skin horse-power, and then rises above it, the skin horse-power, of course, always varying as $v^{2\cdot83}$.

Fig. 2 gives a typical curve of horse-power, *AA* being the curve of effective horse-power, with 100 as its value at the limiting or unit speed. Curve *BB* gives the skin horse-power, and curve *CC* the wave horse-power. The curves were not taken below 0.6 of the limiting speed, as it is not necessary to do so for the present purpose.

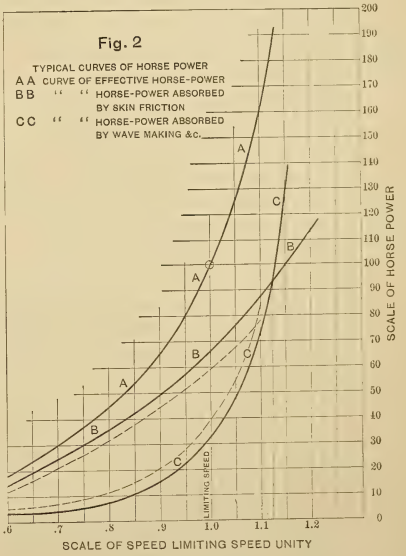
The ratio of wave horse-power to skin horse-power at the limiting speed depends, of course, upon the form of entrance and run and the mean girth of the vessel up to the water-line; but one-half seems to be a fair average value for vessels of fine entrance and run and full midship section. If the midship section is fined, and the wetted surface thereby reduced for the same block coefficient, it naturally follows that the entrance, or run, or both, must be filled out, with the effect that the skin resistance is reduced, and the wave making increased, bringing the curves of skin horse-power and wave horse-power more closely together, as indicated by the dotted curves on the diagram, and bringing the point where skin horse-power is equal to wave horse-power to a lower speed.

It is, therefore, impossible to lay down general rules to meet all cases, as the variations which may occur are almost infinite in number, and so only an indication of the kind of thing that may be expected can be given. Considerations of stability, involving beam, or fullness of water-line, or of girth, which affects weight of hull, more especially if the vessel is to be built to Lloyd's rules, or the question of docking facilities, are merely examples of what the designer has to take account of, and they often hamper him in adopting what he knows would be a better form, or more suitable dimensions for the speed than those he is compelled to take.

The results obtained are from the trials of vessels of good form for the coefficients of fineness they possess. But there are many ships whose performances are not so good as here indicated, and there are others, again, with better performances; the latter, however, generally speaking, appear to have had rather better propulsive coefficients than the 50 per cent. assumed, one or two examples apparently having values of 57 to 58 per cent. The values of the Admiralty constant,

$$\frac{D^{\frac{2}{3}}v^3}{I.\ H.\ P.}$$

at the limiting speed, as found above,



are fairly uniform, varying, however, with the size of ship as given by the table below:—

Length of Ship on Waterline. Feet.	Value of C at Limiting Speed.	Value of C when Skin H.P.=Wave H.P.
200	225	188
300	256	207
400	278	224
500	295	237
600	310	246

These values of C are less for the smaller ships, on account of the higher coefficient of friction for the shorter length of vessel, and also on account of the error in the assumption of the general truth of the law of comparison when applied to the whole resistance. These two causes are not, however, sufficient of themselves to account for the decrease in the value of C. This decrease is partly due to eddy making, caused by minor projections and irregularities in the surface of the smaller ships, these irregularities being on a proportionately larger scale in the smaller than in the larger vessel. It must also be borne in mind that any roughness of sea or wind has a greater effect in proportion on the smaller ships, tending to spoil their performances on trial, as compared with those of larger ships.

I do not intend, when I use the term "economical" speed, to make it include the financial side of the question, as it frequently happens that it is cheaper to increase horse-power, to get a little extra speed when required, than to increase the length of the ship, or to fine her lines. What I intend to convey is that, if a speed be aimed at slightly above the limiting speed I have defined, with the indicated horse-power increasing as more than the fourth power of the speed, it will be found possible to drive at that speed, with the same horse-power, a vessel increased in one dimension, viz., in length, and proportionally increased in displacement; whilst, if a still higher speed be aimed at, the vessel may be increased in two dimensions, viz., length and draught, or length and beam, and still attain the higher speed, with the same horse-power as the smaller ship. Finally, as was proved by the late Mr. Froude, when the indicated horse-power is increasing as the seventh power of the speed, it is possible to drive a similar ship, increased in all three dimensions, at the same speed, with the same horse-power as the smaller vessel, and this is more than borne out by the facts.

I have shown that the indicated horse-power is usually increasing as v^n, when skin horse-power = wave horse-power, or at about 12 per cent. above the limiting speed. This is then the speed at which it becomes economical to increase all the dimensions of the ship in the same proportion, of course, from the point of view of driving the greatest displacement at the given speed.

There are many vessels in which this limiting speed is far exceeded, such as fast cross-Channel passenger vessels, torpedo gunboats and destroyers; but these types are for very special requirements, and are not economical in the sense of carrying large displacement at the required speed. They are not, therefore, included in the scope of this paper. Nor do the figures here given apply to vessels of very great beam in proportion to their length. The examples taken are all of ordinary proportions, not less than six and one-half beams in length, and of ordinary draughts; but, as this includes practically all mercantile vessels, and also cruisers of the usual dimensions, the range is fairly wide.

In these two latter classes the number of indicated horse-powers per ton of displacement rarely exceeds two. In the slower vessels of the mercantile marine it goes as low as ¼ indicated horse-power per ton of displacement. In the torpedo-boat destroyers it goes as high as 20, and in the recently wrecked *Viper*, with the turbine machinery, had reached about 30. The exclusion, therefore, of these very fast craft from a paper dealing with the economical side of the speed and horse-power problem is obviously reasonable. The very broad vessels, also to some extent abnormal, have, therefore, been excluded, as have also the performances of paddle boats.

As regards the comparative performances of single and twin-screw vessels, there appears to be little difference in vessels of good form.

Reverting to the limiting economical speed as defined, I find that, generally, for 1 per cent. increase above this limit of speed, 5 per cent. increase of horse-power is necessary; and at the speed when skin horse-power = wave horse-power, or about 12 per cent. above the

limiting speed, 1 per cent. increase of speed requires 10 per cent. increase of power.

Taking these figures, it appears to me that any increase of speed above the limits indicated should be most carefully weighed before adopting it, in view of the disproportionate increase in power and weight of machinery thereby rendered necessary, together with increased engine room staff, the larger coal bill, and the reduced weight and capacity for cargo. There are ships that might well have been made finer, or have had their speed and power reduced when in the design stage, at the cost of foregoing that last half knot, which possibly requires from 20 to 25 per cent. additional horse-power, enabling the vessel, perhaps, to steam a distance of twelve knots further in twenty-four hours at the cost of burning up coal which would keep her a whole extra day at sea at half a knot less speed, and this without taking into account the original saving in weight and cost of machinery which might have been made.

MODERN MACHINE TOOLS

A COMPARISON OF SOME BRITISH AND AMERICAN DESIGNS

By Ewart C. Amos, Mem. Inst. M. E.

ABOUT the year 1869 a comparatively small business was started in London by Mr. Charles Churchill in the sale of light American hand and machine tools, vises, chucks, and a variety of ingenious appliances which were readily appreciated. The enterprise met with a fair amount of success, but it was not until a few years later, about 1874, that the American machine tool proper, that is, the power-driven machine, began to find its way into the British market. It is interesting to note that it was about that year that the Brown & Sharpe universal milling machines first came to Great Britain, and were sold for £180, while the present price, and for a better machine, too, is somewhere about £106.

It is probable that the cycle boom of 1892 to 1898 did as much as anything to pave the way for the American invasion of Great Britain, and since then American machines have come over in increasing quantities. Whilst, therefore, their introduction, and to some extent their continued sale up to the present time, may largely be ascribed to the demand for tools of which the British manufacturer was unable to provide an adequate supply, this alone is not sufficient to explain their undoubted great popularity. Indeed, it must be admitted that the American designer has in many ways got ahead of his British confrère. In what ways will presently be shown, but it is now evident that the imported tool is no longer sought for

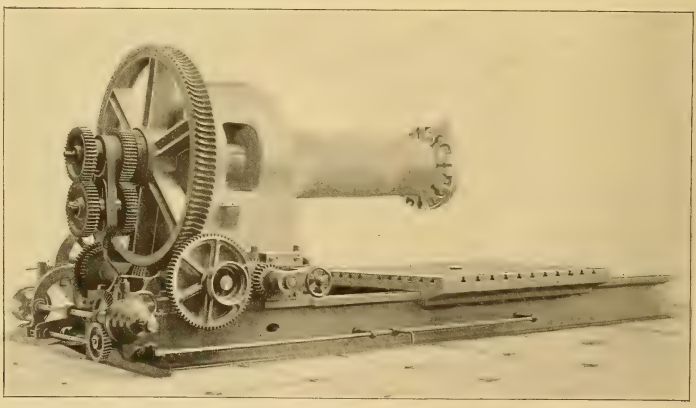


FIG. 1.—SNOUT BORING MACHINE BUILT BY MESSRS. JOSHUA BUCKTON & CO., LTD., LEEDS, ENGLAND

simply as a stop-gap, and because British tools are unavailable, but because the principles which the American machines embody are sound, and comply with the exacting modern requirements. In addition to this comes the fact that the British tool maker has himself been glad to increase his plant by purchases from abroad. In the past, therefore, and up to the present also, British makers have suffered but little from foreign encroachments. Whether the same condition of things will pertain in the future will depend on the ability of the maker has very much to unlearn, and it is not really his incapability but his rooted objection to change, that calls for attention.

It is the writer's object in this article to consider the differences between, and the advantages of, some of the several makes of British and American tools, though obviously within magazine limits it is difficult to present a selection of designs which shall be fairly representative of the two types and do justice to the various makers. There are many more first-class and really representative

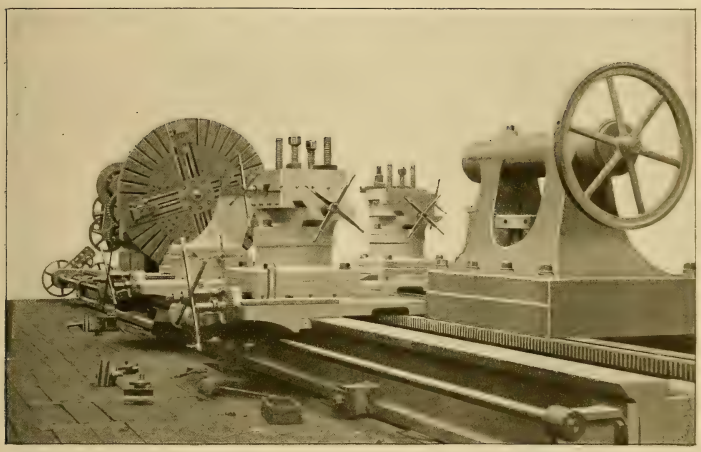


FIG. 2.—A 60-INCH CENTRE LATHE, BUILT BY SIR WM. G. ARMSTRONG, WHITWORTH & CO., LTD., NEWCASTLE-ON-TYNE, ENGLAND

British tool maker to supply tools equal in design to those of his competitors, because even if the present demand be sustained, this, in time, will not alone be sufficient to enable Great Britain to hold her own. There is every indication, however, that British makers have not only recognised that many of the old type of machines are no longer salable, but also that there is a growing demand for a number of special machines which they can make quite as well as anyone else if they will give the matter the same amount of attention as is given to it in the United States. It is here that much of the difficulty lies. The British tool builders in both countries than it is possible to refer to here even with one illustration, and there are several hundred different kinds of machines, not necessarily different types, but yet possessing such divergence in detail as to be all worthy of consideration. Many of the standard types are not referred to at all, in order to make room for some of the special machines which are considered likely to prove more interesting.

In the construction of powerful machines the British tool maker has always excelled. Take, for instance, the special 30½-inch centre triple-geared propeller shaft lathe of Messrs. Sharp

Stewart & Co., Ltd., the special snout boring machine of Messrs. Joshua Buckton & Co., or, again, the massive 5-foot centre screw-cutting lathe of Sir Wm. G. Armstrong, Whitworth & Co., Ltd., all of which are here illustrated, and which will be referred to in detail later on. These are fine examples of their kind, and it is doubtful whether they can be surpassed by anything constructed in any other country. The somewhat adverse remarks made by the author in several parts of this article are not directed to this class of tool or to any of those illustrated and referred to in this article.

The Sharp Stewart propeller lathe illustrated in Fig. 12will take shafts up to 40 feet long, and clear 4 feet diameter over the top of the saddles. Of these there are two in number, each being fitted with two sets of compound slide rests, the front sets having a swivel slide and an extra cutting slide at the top for putting on the feed independently of the surfacing screws in the saddle. The fast headstock is driven through a five-speed cone, and one single, two sets of double, and two sets of triple gear giving twenty-five changes of speed to the spindle. With a cutting speed of 15 feet per minute, the belt has a minimum speed of 1125 feet per minute. Since all the driving is through the face plate, all driving torsion on the spindle is avoided. At the fast headstock-end the bed is brought out with two spurs to support the part carrying the gearing, and at the same time to reduce vibration. The feed motions effect sliding, surfacing, and screw-cutting, the leading screw being placed in the centre of the bed, and either saddle is independent of the other. This type of lathe is specially adapted for turning propeller shafts, gun tubes, connecting-

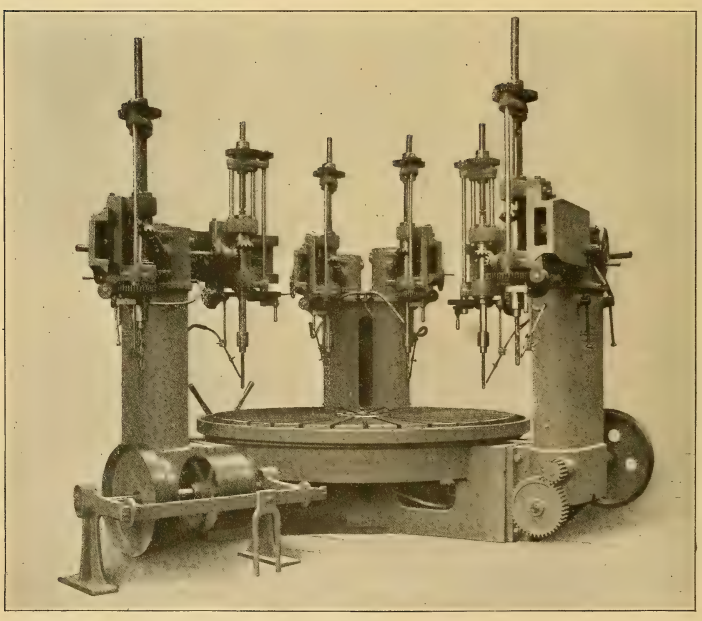


FIG. 3.—A MULTIPLE ARM RADIAL DRILL, BUILT BY MESSRS. BEVER, PEACOCK & CO., LTD., MANCHESTER, ENGLAND

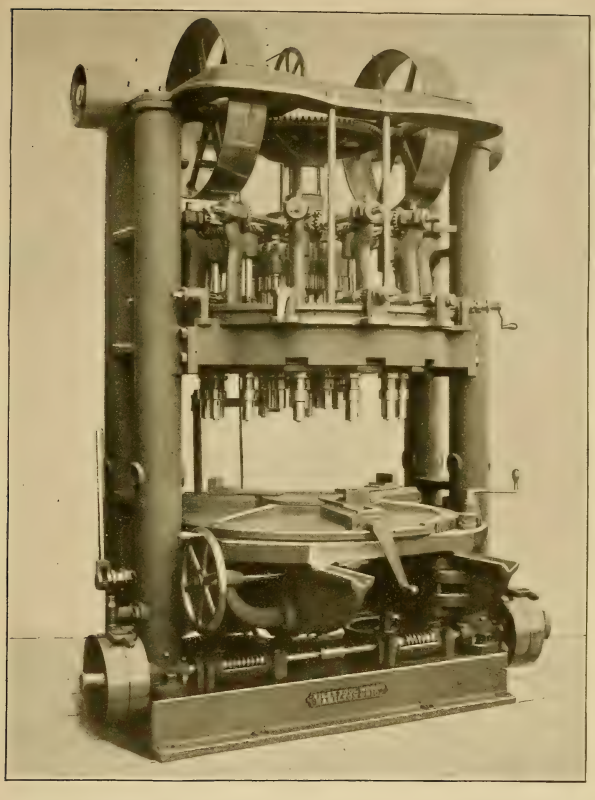


FIG. 4.—MULTIPLE SPINDLE DRILL FOR DRILLING STEEL-TIRED CAR WHEELS, BUILT BY THE NILES TOOL WORKS CO., HAMILTON, OHIO, U. S. A.

rods, and other similar work, and is a good representative modern lathe of heavy type.

The Buckton snout boring machine, shown in Fig. 1, is a very valuable, although somewhat uncommon, type of tool. This particular example represents one of the latest and largest made by Messrs. Buckton, and it is also interesting to note that it is designed to be driven either by belt or by an independent electric motor. The question of electric driving is rapidly coming to the front, and it is a good sign that leading British manufacturers are not behind in recognising this fact. The prominent feature in this particular machine is the long snout. This carries the boring head which projects into the cylinder to be bored. By this arrangement it is possible to bore up to a dead end, as, for instance, a cylinder with the end cast in solid, without any boring bar or stay being required. The machine will bore and face cylinders and liners for marine engines up to 6 feet diameter by 6 feet length, and is equally suitable for a variety of other work, such as boring gun hoops, for example. The cutter head is carried on the end of a spindle

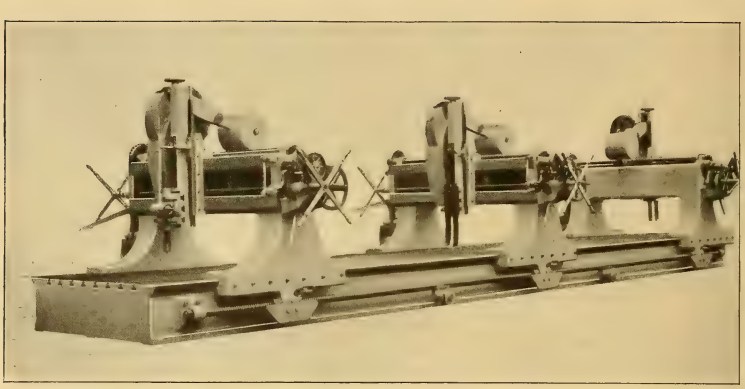


FIG. 5.—TRIPLE-HEAD SLOTTING MACHINE BUILT BY SIR WM. G. ARMSTRONG, WHITWORTH & CO., LTD., NEWCASTLE-ON-TYNE

which passes through the massive snout, and has keyed on its back end the big worm-wheel by which it is rotated. The table carrying the work moves forward to give the required feed. The boring head is supported at a constant distance from its base, and the deflection is a constant quantity, so that, except for the decrease in diameter due to the wear of the tool, the hole bored is parallel and free from the bellying which results when boring with a machine in which the distance of the cutting tool from the point of support is continually changing. The table has a quick power traverse, as well as a variable, self-acting feed motion, and for facing the ends of cylinders and other similar work a duplex arbour rest is substituted for the boring head. Such a machine, besides affording great facility for fixing and removing work, will be found exceedingly useful in many ways.

The Whitworth screw-cutting lathe, shown in Fig. 2, is a very powerful 60-inch centre lathe fitted with a 60-foot bed, and is designed for sliding, surfacing, screw-cutting, and coning, and has recently been erected in a works at Vladivostok, Russia. It has a double bed, 11 feet wide, the centre bed forming a slide for the headstocks to work on, and a side-bed back and front for carrying the rests. There are two guide screws, and four saddles, two of which have ordinary top rests, and two have crank rests, interchangeable. The front bearing is 20 inches in diameter, and the face plate is 10 feet in diameter. The total weight is 165 tons. It is needless to add that the workmanship is of the highest class.

In Figs. 3 and 4 two special machines are shown, one a multiple radial arm drill, by Messrs. Beyer, Peacock & Co., Ltd., of Manchester, England, and the other a multiple spindle wheel drill, by the Niles Tool Works Company, of Hamilton, Ohio, U. S. A. The Beyer-Peacock machine is designed for drilling holes in large circular articles, such as the retaining rings and rims of locomotive wheels for securing the tires, and is adapted to other similar purposes, whilst the American tool is for drilling steel-tired car wheels. In this machine the spindles are arranged in two groups, the centre ring of spindles, nine in number, being used for drilling the holes for the hub bolts, whilst the other group or ring has eighteen drills, which are for drilling the holes for the tire bolts.

In the British machine there are three vertical columns bolted to a massive box base plate. Upon this rotates a circular table 6 feet 8 inches in diameter Work six feet in diameter can be put on the table between any two of the columns,

but when the radial arms are swung clear, work up to 7 feet 9 inches diameter can, by lifting it clear over the top of the column, be placed upon the table. Each column carries two radial arms with a swing of 3 feet, and capable of reaching within 18 inches of the centre of the table, and upon these arms slide the spindle saddles. Each spindle is fitted with two speeds, and runs in adjustable conical bearings. Independent, self-acting feed motions are provided for drilling holes 15 inches deep, the extreme distance from the table to the centre of the nose being 23 inches. The drills are driven simultaneously, but each has an independent stopping and starting motion.

In the American tool there are twenty-seven spindles in all, provided with suitable adjustment to enable all the drill heads, or some of them, to be moved in or out radially to suit different diameters. Each group of spindles is driven separately, and each spindle is adjustable for height. The feed is effected by two heavy steel screws placed under the table, the work being lifted up to the drills. These screws, as reference to the illustration will show, are driven by fast and loose pulleys, provided with a belt shifter through which the feed can be instantly stopped. The work is carried on a compound table having a self-centering chuck, with circular motion for any desired adjustment of wheels under drills, and to secure rapid and easy vertical adjustment of the table by hand it is counterbalanced by a weight placed under the sole plate. In order to facilitate handling of the work, the chuck table is mounted on *V*-slides, thus enabling it to be brought out from under the drills, when it can easily be lifted up by a hoist or otherwise. Such a machine is capable of turning out the work very rapidly, and, although somewhat complicated in appearance, is easily adjusted to suit the varying requirements.

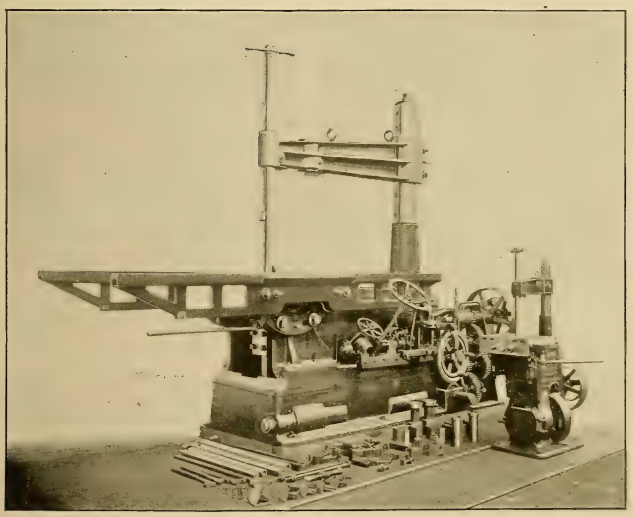


FIG. 6.—THE COLBURN KEYWAY CUTTING MACHINE, MADE BY MESSRS. BAKER BROS., TOLEDO, OHIO, U. S. A

The next two machines, shown in Figs. 5 and 6, are again by British and

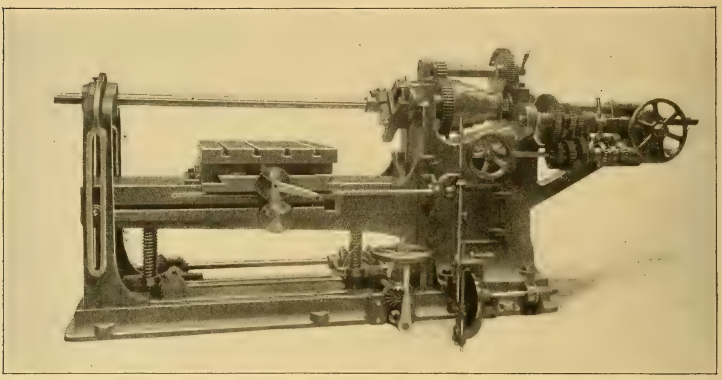


FIG. 7.—HORIZONTAL BORING MACHINE MADE BY MESSRS. J. BUTLER & CO., HALIFAX, ENGLAND

American makers, respectively, and while widely different in design, belong to the same group, since they both have a slotting action. The ordinary slotter forms one of the most useful of the standard types of machines, but its action is well known, and the improvements effected in its general construction do not call for any special reference here. The two here illustrated are, however, quite special, the first being a very powerful triple-head machine built by Sir W. G. Armstrong, Whitworth & Co., Ltd., specially designed for slotting the curves and straight portions of locomotive frames and taking in work up to 36 feet long by 5 feet 6 inches wide.

The rams have an adjustable stroke up to 15 inches, and will deal with a number of plates laid one upon the other. The machine consists of a massive bed upon which are mounted three heads or cross frames. These are driven from one long shaft running along one side of the bed, but each head can be stopped or started independently of the other by means of friction clutches on

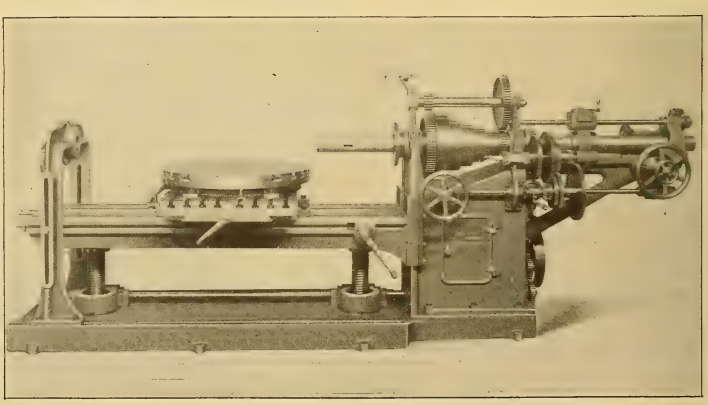


FIG. 8.—A SIMILAR MACHINE, MADE BY THE NILES TOOL WORKS CO., HAMILTON, OHIO, U. S. A.

the far upright. Each head can be either fed along the bed when slotting, or can be moved along the bed quickly to any desired position independently of the other by means of the long stationary screw on the front of the bed and reversing gear on the back of each upright. Each slotting head has a hand and self-acting feed in either direction, and by a combination of the two feeds, *i. e.*, the transverse and the longitudinal, curves can be slotted out. The machine is universal, since all the motion can be worked independently or together, and in any direction, whilst the rams also can all be working at different strokes if desired.

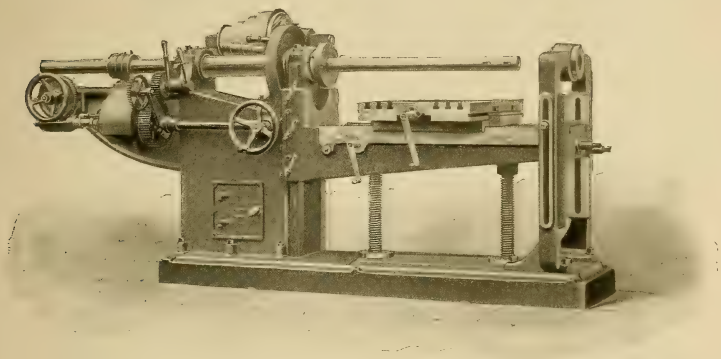


FIG. 9.—ONE OF THE BORING MACHINES MADE BY THE NEWARK MACHINE TOOL WORKS, NEWARK, N. J., U. S. A.

The second machine, which is a Colburn keyway cutter, introduced into Great Britain by Messrs. Charles Churchill & Co., Ltd., of London, is not a slotter as ordinarily understood, although its object is to cut keyways, a class of work which, up to a few years ago, was usually performed in an ordinary slotting machine, and is so still performed in many shops. This is a type of machine which has received comparatively little attention by British manufacturers, although there are one or two good British makes on the market. This is difficult to understand, as the value of such a tool cannot be overestimated, and when once used for keyway cutting and the several other purposes for which it has attachments, it will never be discarded. The author was requested a year or two back to find a suitable machine for slotting hexagon shaped holes, measuring about 2 inches across the flats, in steel castings, and put in one of these machines, which proved very satisfactory and far more efficient than an ordinary slotting machine. As to the speed at which keyways can be accurately cut, a keyway half an inch wide and 2 inches long can be cut in a cast-iron gear wheel in one minute, and this includes the time taken for chucking.

The special feature of this particular type of keyway cutting machine is the rigid support afforded to the upper as well as the lower part of the cutter bar by means of a column and projecting arm. This arrangement secures a perfectly straight cut throughout the stroke. It does not in any way limit the diameter of the wheel to be "keywayed," since the arm can readily be removed and the wheel slipped over the column, or should the rim or an arm still foul the column, provision is made for the latter to be shifted into another position. This adjustment, together with reversing the cutter in the bar, and cutting from the rear instead of the front, almost invariably enables the rim and

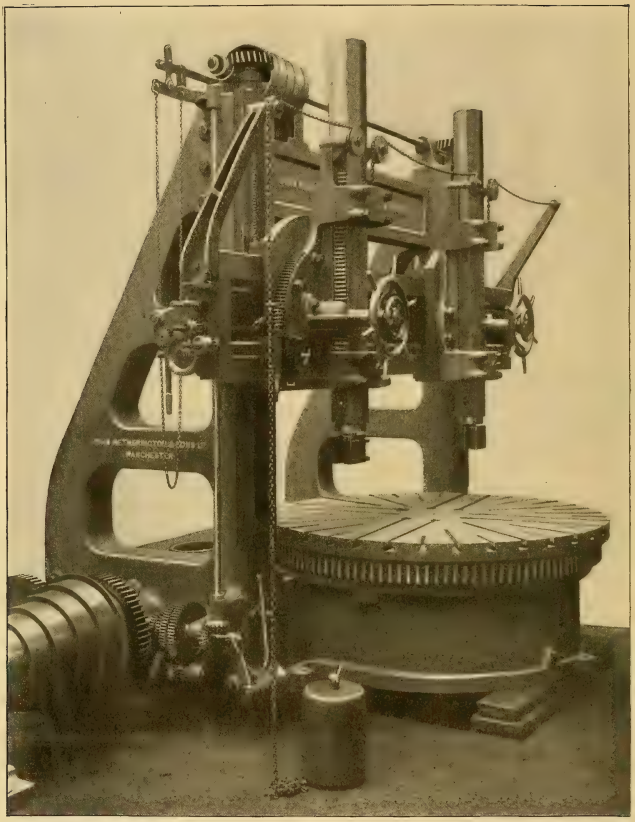


FIG. 10.—VERTICAL BORING AND TURNING MILL BUILT BY MESSRS. JOHN HETHERINGTON & SONS, LTD., MANCHESTER, ENGLAND

arms to clear the column. Various attachments enable the machine to be used for making keys, cutting racks, sawing metal, and other work. The illustration shows, side by side, the largest and smallest sizes made.

A type of tool which is probably amongst the most useful of any in a modern machine shop is a boring machine of the kind shown in Figs. 7 and 8, a British and an American make being selected. One is from the works of Messrs. J. Butler & Co., and the other from the Niles Tool Works Company. These are very good examples of how closely the two makes resemble each other, and if all British tool makers showed the same enterprise in bringing their machines up to date, as in the Butler machine, we would not hear so much about American competition. As the general design of both machines is the same, it is unnecessary to describe each in detail; moreover, the arrangement of the principal parts is clearly shown in the illustrations. It may be

noted, however, that the tables have hand and power elevating gears, and that the boring bar bracket slides along the base end and on the sides of the table, and can be clamped in any position. As shown in the American machine, a loose table is fitted on to the main table, with transverse slide and revolving top, also self-acting, reversible feed motion for milling purposes. The facilities offered by this type of machine for clamping work to the table and bringing it into position for drilling, boring, or milling, are almost equal to those of the universal milling machine, and at the same time the machine will deal with much heavier work. Still another American tool of this class is shown in Fig. 9, — a product of the Newark Machine Tool Works, of Newark, N. J.

Prominent amongst the machines imported from America is the vertical boring and turning mill, and it is certain that American engineers are largely responsible for its extended use in Great Britain. This is the more singular, since machines of this type were built in Great Britain twenty to thirty years ago, and more, and there is reason to believe also that they were originally designed by British makers; but until recent years users in Great Britain did not appear to appreciate them to any great extent. Now, however, British works turn out and sell large numbers of very fine machines of this class, a

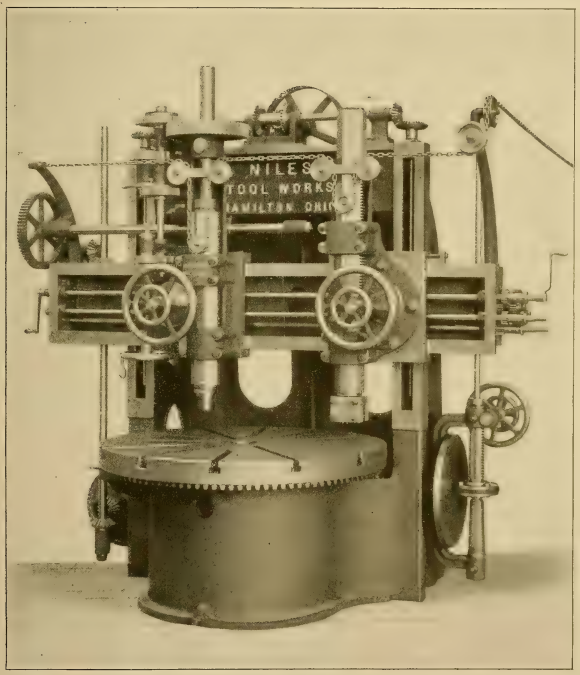


FIG. 11.—VERTICAL BORING MILL BUILT BY THE NILES TOOL WORKS CO., HAMILTON, OHIO, U. S. A.

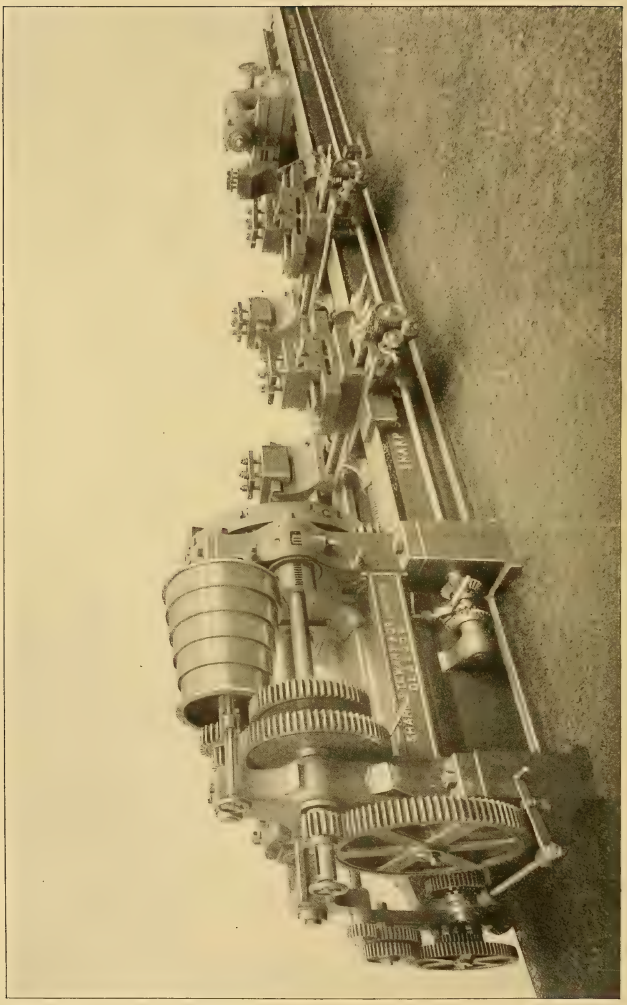


FIG. 12.—A LATHE FOR PROPELLER SHAFTING AND GUN TUBES, BUILT BY MESSRS. SHARP STEWART & CO., LTD., GLASGOW

good example being the Hetherington machine, shown in Fig. 10. This machine takes in work 9 feet in diameter by 4 feet 6 inches deep, the table or face plate being 8 feet in diameter. The ram has a vertical and an angular traverse of 3 feet, and the machine weighs about twenty-three tons. There is no doubt that the facilities offered by a machine of this kind for chucking work and taking heavy cuts, owing to the face plate types favour friction driving. It may be interesting to give a few leading dimensions of a large boring mill recently built by the Manchester firm to whose machine reference has just been made. This machine will take in 32 feet diameter by 6 feet deep under the tool holder, the table being 19 feet in diameter. The rams, which are of octagonal section, have a 4-foot, self-acting feed, and measure 9½ inches across the

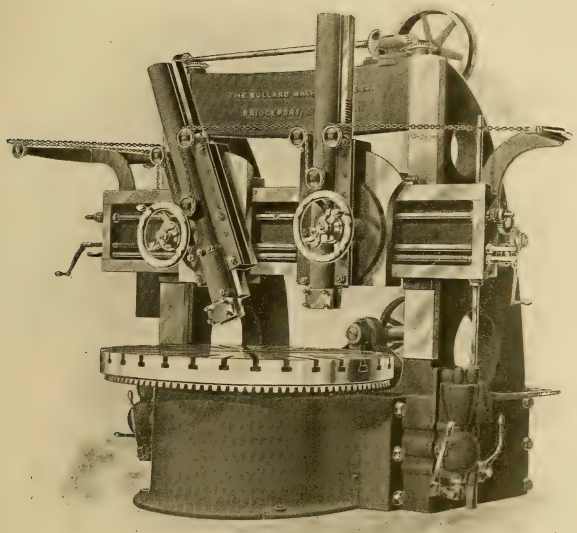


FIG. 13.—BORING AND TURNING MILL BUILT BY THE BULLARD MACHINE TOOL COMPANY, BRIDGEPORT, CONN., U. S. A.

being horizontal, gives them a considerable advantage over the ordinary lathe.

There is not a great difference between the British and the American tool, the most noticeable, perhaps, being in the method of applying the feed motion, as British machines are mostly positively driven, whilst the American flats. The spindle for the table is 24 inches in diameter, with a 26-inch length of bearing. The feeds are independent, and range from one-sixteenth-inch up to three-fourths of an inch per revolution of the table. The purchase of gearing is 760 to 1, and the machine complete weighs 116 tons. It is a fine example of its kind.

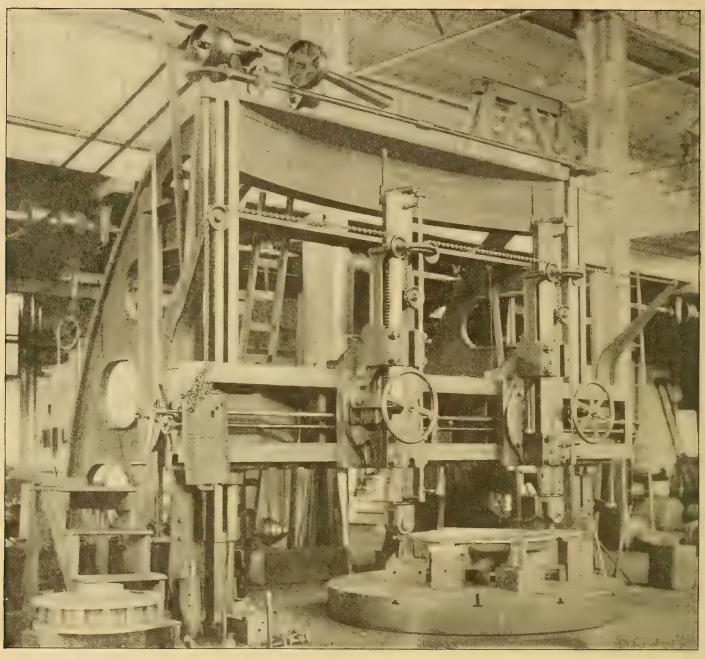


FIG. 14.—A BORING MACHINE BUILT BY THE BETTS MACHINE CO., WILMINGTON, DEL., U. S. A., IN THE MAIN MACHINE SHOP OF THE HARLAN & HOLLINGSWORTH COMPANY

The American boring machine shown in Fig. 11 is from the Niles Tool Works Company. This firm, as is well known, are very actively pushing American machines of powerful construction in Great Britain, and appear to find as ready a market for the heavier types as some of their competitors are finding for the lighter kind. The machine illustrated shows one of the latest types, with one of the tool holders fitted with a revolving spindle which can be run at a speed suitable for boring the centre of a wheel whilst the other tool is turning, or it can be used for boring and turning crank-pins and shaft holes without removing the work after it has once been secured. A similar device is fitted to the Bullard mill, another well-known American make, shown in Fig. 13. In the Niles machine the friction feed is clearly seen, as is also the power lifting gear for the cross slide.

In Fig. 14 is shown, as of further interest here, one of the machines built by the Betts Machine Company, of Wilmington, Del. This class of machine now fills such an important position in the machine shop that no excuse is needed for showing, in Fig 15, an illustration of a single-standard pattern of British construction by Messrs. J. Butler & Co. The general design and arrangement of the working parts is clearly seen from the cut. It will take in work 40 inches in diameter and 26 inches high, and is double-geared. It is specially designed for boring and turning small cylinders, valves, pulleys, and similar work. As in most boring mills of this type, the table can be raised off the large bearing which supports it

when required to run lightly and quickly by means of a screw at the footstep. The table, it will be noted, is placed at one side of the standard, which brings the tool, when in its centre position on the cross slide, immediately over the work for turning. The machine is fitted with the usual automatic feed motions, and weighs three and one-half tons.

Milling machines have rapidly come to the front of late years and have almost superseded the shaper, planer, and slotter for certain classes of work, and the immense variety of design in which they are now made really calls for a special article. Only very brief reference will, therefore, be made here to a few of the host of designs,—to the Ward-Lincoln type miller for example, shown in Fig. 16, and the Beaman & Smith duplex machine, in Fig. 17. The former is interesting from the point of view of being a solidly built British machine on American lines, and possessing also some good features of its own. The machine is suitable for heavy duty, and has a traverse on the table of 3 feet by 20 inches, with a vertical traverse of the milling head of 20 inches, which is arranged with a reversing motion so that cuts may be taken up or down. There is also a self-tripping motion to determine the length of travel automatically. The spindle is 4¾ inches in diameter in the front bearing and 3½ inches in the back bearing, and runs in adjustable bronze bushes. The spindle-drive is geared from 12 to 1, and is very powerful. The feed motions are obtained by the use of friction discs, and these can all be quickly adjusted from one side of the machine, where all the operating handles are within easy reach of one another.

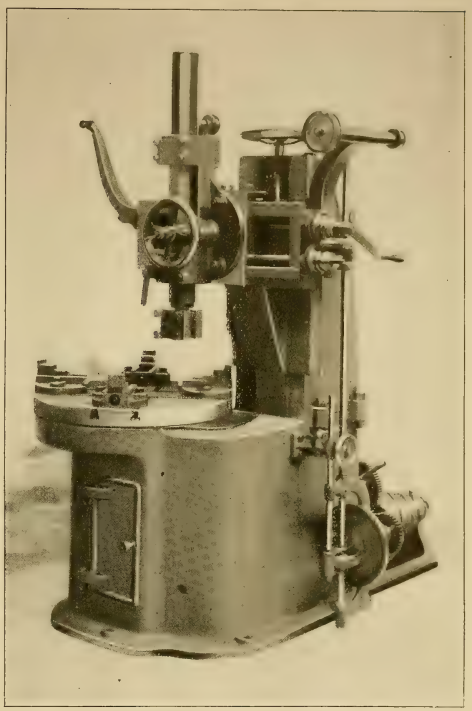


FIG. 15.—A SINGLE-STANDARD BORING MILL MADE BY MESSRS. J. BUTLER & CO., HALIFAX, ENGLAND

In the Beaman & Smith design the heads carrying the spindle have a horizontal movement only, whilst the work is carried on a rising and falling table working on slides in the middle of the machine. The ends of the spindle close up to 5 inches and open out to 48 inches. The table is 54 inches long by 14 inches wide, with an automatic transverse feed of 48 inches, and rises and falls 11 inches. The spindles are driven by a five-speed cone, placed at the back of the machine, on to bevel and spur gearing, as shown. The machine weighs about three and one-half tons.

The next two machines to which atten-

tion is directed are a Muir and a Garvin vertical miller, again British and American, the former by a well-known Manchester firm, whose reputation for high-class work is well established, and the latter by the Garvin Machine Tool Company, of New York, introduced into Great Britain by Messrs. Burton, Griffiths & Co., of London. Taking the British tool first, as shown in Fig. 18, it will be seen that it is of that very useful type, the Universal, and is capable of dealing with a great variety of work, as the headstock is arranged to swivel, and is fitted with both a horizontal and a vertical spindle driven by independent belts, the former being also provided with a crosshead and stay for supporting the cutter mandrel. The table is arranged to swivel through 45° right or left hand for cutting skew gears, and is fitted with the usual self-acting slides, the longitudinal and vertical having index adjustment to the thousandth part of an inch. The machine illustrated is double-geared, and the vertical spindle will admit work 20 inches in diameter, while the horizontal will take in 18 inches from centre of spindle to top of table when at the lowest point. The weight of the machine is about two and one-quarter tons.

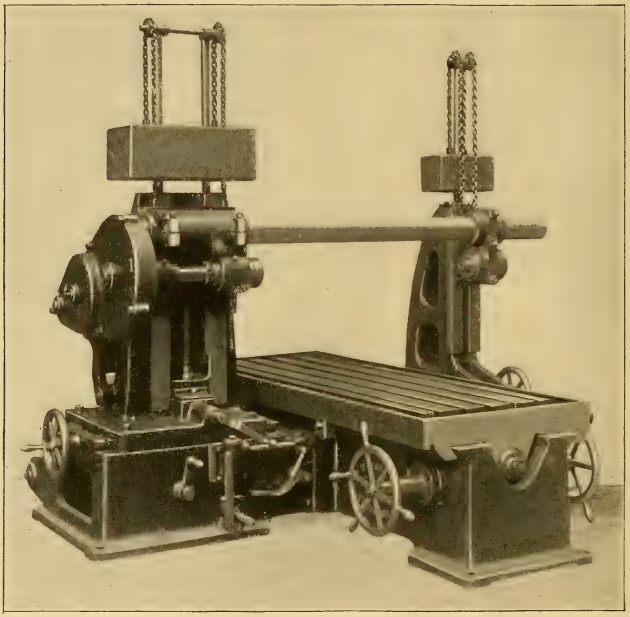


FIG. 16.—HEAVY-DUTY MILLING MACHINE BUILT BY MESSRS. H. W. WARD & CO., BIRMINGHAM, ENGLAND

A special feature of the Garvin machine, shown in Fig. 19, is the method adopted for controlling the power feeds. These are provided in all directions, and all are thrown in, tripped or reversed by the single handle seen at the side of the machine. Any desired speed is instantly obtained by simply setting the handle to the corresponding number on the index plate. There are eighteen

changes of feed, ranging from one-three-hundredths inch to one-eighth inch. The in-and-out and vertical adjustments have micrometer readings. The rotary table has also both hand and power feeds.

Like the milling machine, the capstan or turret lathe, with its almost infinite variety, requires separate treatment, and no attempt will be made here to describe its development. Some reference is, however, necessary in respect to a machine which occupies such a very important position in machine shops today. As is known, it has largely superseded the ordinary lathe, which until the last few years was made to do everything in the way of turning. So far as British manufacturers are concerned, they have been well to the front in this class of tool, and those firms who have made it a specialty have more than held their own against foreign competition. The only thing to be regretted is that not more British firms build them.

Prominent in this line are Messrs. Alfred Herbert, Ltd., of Coventry, one of whose machines is illustrated in Fig. 20. The lathe shown is what is known as a No. 6 patent chasing saddle lathe, and is specially designed for turning out repetition work of large dimensions, and of a wide range. The headstock has a hollow steel spindle with a 2-inch hole through it, and the flange for carrying the chucks is forged solid with the spindle. The headstock is provided with two sets of back gearing, giving ratios of 4 to 1 and 15.7 to 1, and these gears are engaged by means of clutches which can be operated whilst the lathe is in motion. The gearing, therefore, in conjunction with two speeds on the countershaft, gives six graduated speeds on each step of the cone without moving the belt or stopping the lathe. This arrangement should prove a great time-saver over the ordinary methods of changing the speeds, and also encourages the operator to machine his work at the proper speed.

The lathe is fitted with a large hexagonal turret, sliding on the bed, and in addition has a saddle carrying a supplemental turret to take four tools. It will cut large or small screws, with right or left-hand threads, in addition to all kinds of chuck work, and is fitted with a three-jaw universal, a four-jaw independent, and a two-jaw or revolving

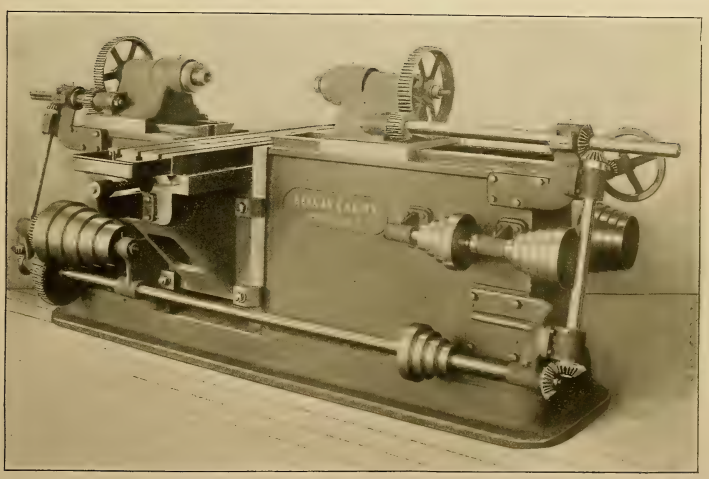


FIG. 17.—DUPLEX MILLING MACHINE BUILT BY THE BEAMAN & SMITH CO., PROVIDENCE, R. I., U. S. A.

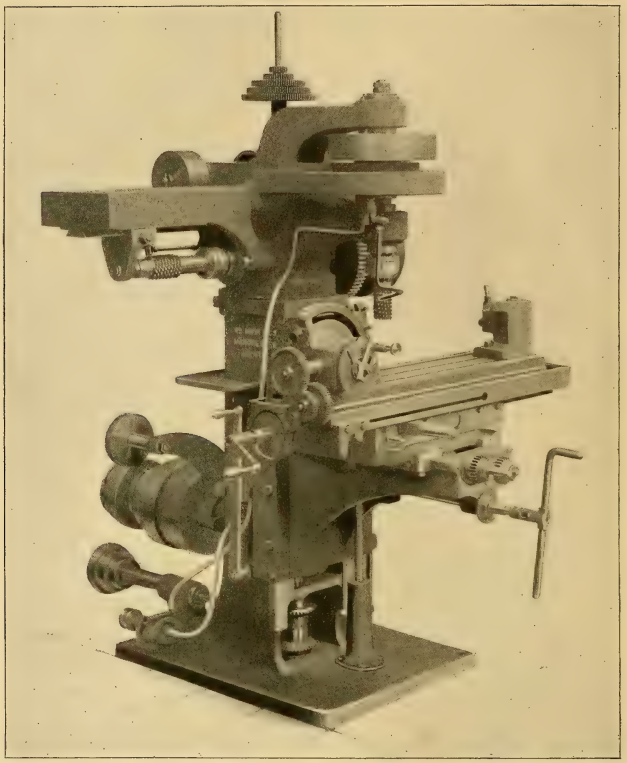


FIG. 18.—MILLING MACHINE MADE BY MESSRS. WM. MUIR & CO., MANCHESTER, ENGLAND

valve chuck, this latter for holding such work as valves, tees, elbows, etc. Each face of the main hexagonal turret is provided with a hole 3¼ inches in diameter for receiving shank tools, boring bars, etc., and so arranged that long work can pass through the turret. The turret is inclined, and is locked by a plunger immediately under the tool in operation, and for heavy work can be clamped from the outside. It has automatic feed in either direction, with eighteen changes, six of which can be instantaneously obtained without moving the belt upon the feed cone pulley. The eighteen feeds are in two ranges; the fine feeds are suitable for heavy drilling work in steel forgings, and the coarse feeds, which are obtained by the movement of a lever on the turret slide apron, are suitable for boring holes in castings which have been previously cored. The saddle is provided with sliding and surfacing motions giving nine changes of speed in either direction, three of which can be instantaneously obtained without moving the feed belt. The sliding and surfacing motions have each four independent adjustable stops—one for each tool. These trip the feed and also act as dead stops. In addition to this, the saddle is

furnished with independent screw-cutting motions, and right and left-hand threads are cut by simply moving a handle. Each leader will cut four pitches without the use of loose change wheels.

Incidentally, in connection with the subject of lathes and American tools, it may be mentioned that Canadian-built machines are now coming into the British market, and a very good example is shown in Fig. 21, which illustrates a 9-inch centre screw-cutting lathe by Messrs. Bertram & Sons, of Dundas, Ont., Canada. It is a well-designed tool, built entirely on American lines.

Like every other class of machine, the drill has been much improved in recent years, especially in respect to a greater use of balanced spindles giving sensitive feeds, and ball thrusts to reduce friction. Grouping of a number of spindles in one frame is becoming very popular, and universal adjustments

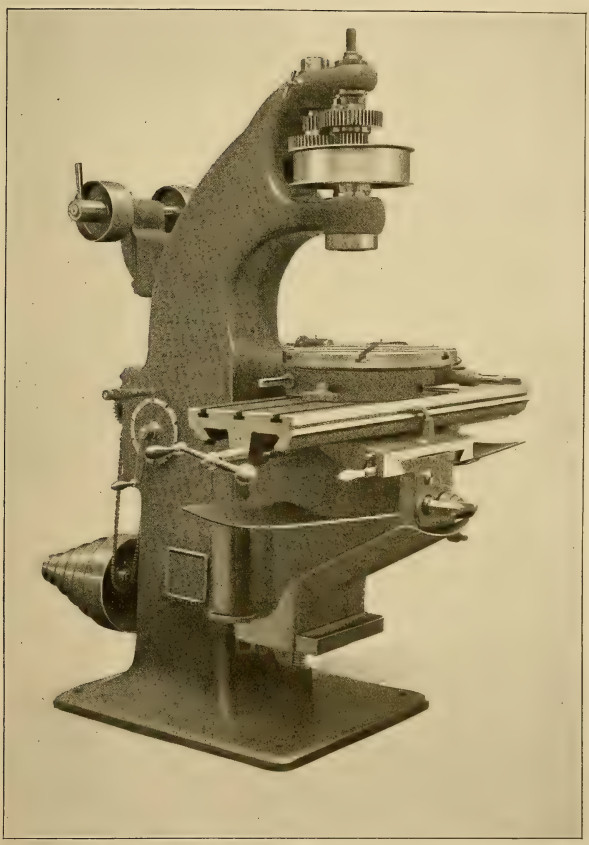


FIG. 19.—VERTICAL MILLING MACHINE MADE BY THE GARVIN MACHINE CO., NEW YORK

are now recognised as essential. The 6-foot arm radial drill by the Atlas Engineering Company, of Manchester, shown in Fig. 22, is a very good British type. The spindle is balanced and fitted with reversing motion for tapping, etc. The table can be set to any angle, from horizontal to vertical.

An American radial drill by the Bickford Drill & Tool Company, of Cincinnati, Ohio, is shown in Fig. 24. The spindle has sixteen changes of speed, ranging from 12 to 280 revolutions per minute, with three changes of feed for each speed, and is provided with both hand and power feed, quick advance and return, hand-lever reverse, accelerated backing speed, and automatic stop. Four of the spindle speeds are furnished by the cone, two by the back gears, and two by a multiplying device on the back of the head, giving four changes of speed for each step of the cone, each of which is instantly available.

Another radial drill, one of the universal type by the Niles Company, is shown in Fig. 23. This has a 7-foot 6-inch arm, and will drill in the centre of a piece of work 12 feet in diameter. The arm is arranged to swing through a complete circle, the driving power being applied through a vertical shaft from the countershaft to gearing at the top of the column. The cones, with their framing, rotate with the arm around the column and act as a balance weight. The column rests on a ball bearing, which insures easy handling. There is a swiveling head and rotating arm, as shown in the illustration, making the machine as universal as possible.

As already mentioned, multiple spindle drills are now much in favour. The one illustrated in Fig. 26, by Messrs. Webster & Bennett, of Coventry, England, has two spindles, and is fitted with independent heads and tables. The driving motion is transmitted through bevel and spur gearing, whilst the spindles themselves have separate automatic feed motions, with trip motion for stopping the feed automatically. They are also balanced and fitted with ball thrust bearings. The tables are arranged to be used either bolted together, for supporting a large piece of work, or they may be used separately. The spindle heads have minimum and maximum centres along the cross slide of 3 inches and 18 inches, respectively.

Brief reference must be made to planing machines, which still remain among the most important machines we have, and notwithstanding the encroachment of the slab and other forms of milling machines. It is generally considered that the American planer is too light for British metal, and such complaint is not

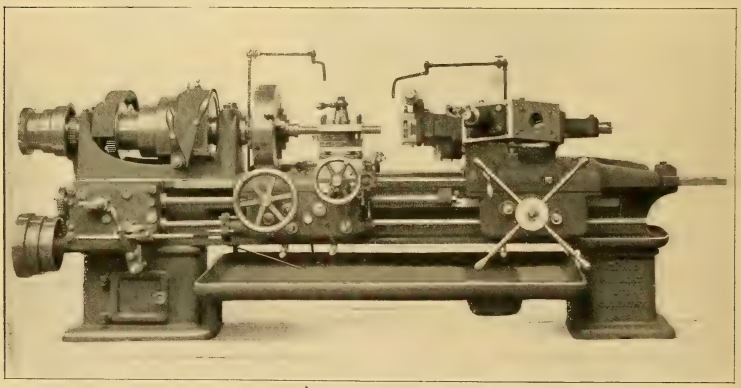


FIG. 20.—TURRET LATHE BUILT BY ALFRED HERBERT, LTD., COVENTRY, ENGLAND

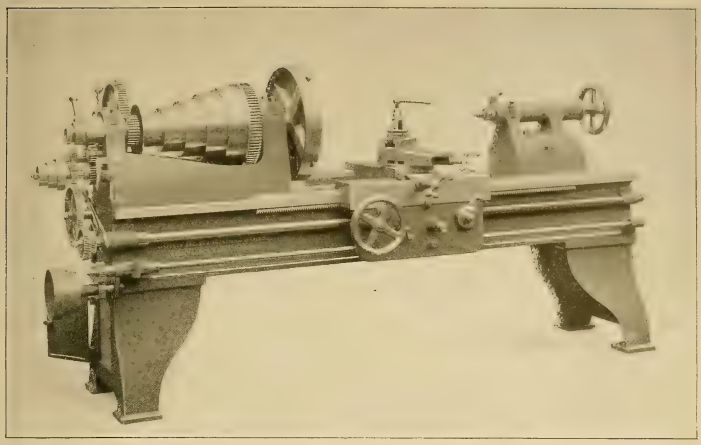


FIG. 21.—SCREW-CUTTING LATHE MADE BY MESSRS. BERTRAM & SONS, DUNDAS, ONT., CANADA

without some foundation. Another defect frequently found in the American machine is that, on account of the soft iron used, the slides wear very rapidly. The remarks in reference to weight do not, however, apply to the Niles planer, shown in Fig. 25. This represents a machine which will plane 5 feet square by 16 feet long, and is of very substantial construction. It is fitted with two tool boxes on the cross slide, and two on the uprights.

The British machine by Messrs. J. Butler & Co., of Halifax, shown in Fig. 27, embodies several interesting features, and is a good example of what some British manufacturers are doing in the way of combining some American ideas with the best British practice in respect to solidity, and strength, and capacity for long usage, for which the best British-built machines have always been noted. One of the features referred to is found in the gearing. This is supported in a separate frame placed inside the bed, and has no bearings in the bed of the machine, as is usually the case in both British and American machines. This improvement enables the gearing to be readily removed if necessary. The tool boxes are designed to revolve completely. The driving arrangement is very compact, and the cutting speed in the size illustrated (12 feet by 4 feet square) is 20 feet per minute, with a return of 80 feet per minute. It is also arranged that the feed is put on at the commencement of the cutting stroke, and not at the finish. On a 2-foot 6-inch square machine of similar construction the cutting and return speeds are 25 feet and 100 feet, respectively. These speeds more than compete with the American.

A machine possessing many advantages is the side planer. The machine shown in Fig. 28 is by Messrs. George Richards & Co., of Broadheath, Manchester, who have made a specialty of this class of tool. Its resemblance to a shaper is striking, the difference, however, of course, being that the saddle carrying the overhanging arm traverses parallel instead of at right angles to the bed. It has this advantage over the ordinary planer, in common with several other types of planers, that the work is stationary whilst the cutting tool moves. It also takes up less room as the length of the machine is only the stroke plus the length of the saddle and driving gear, as against twice the whole

stroke of the machine as in ordinary planers. These machines are fitted with special stopping and reversing motions actuated from the end of the arm, and also with a quick return of 4 to 1. A recent improvement is a ball or roller thrust bearing to take the thrust on the screws. The machines have a large capacity, and will deal with all sorts of irregularly shaped work which would not pass the standards of even a large planer.

Perhaps the most distinctive difference between British methods of constructing machines and those adopted by American makers is found in the fact that the latter build to gauge and in quantities, and that the British maker generally builds to order, usually one machine at a time, or as required. There are exceptions to every rule, and the advantages to be derived from building a batch of a dozen or more machines at a time, especially of the lighter machines, is rapidly being appreciated in Great Britain. Again, Americans specialise, while most British works will make any machine for which they get an order. One has only to inspect the pattern department of many of the small British works to learn this. This is speaking generally, because a number

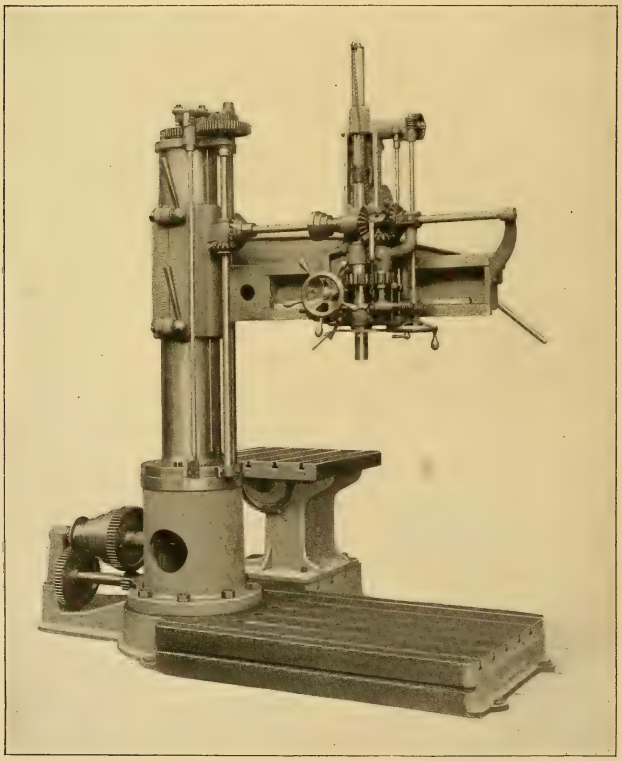


FIG. 22.—RADIAL DRILLING MACHINE BUILT BY THE ATLAS ENGINEERING COMPANY, LEVENSHULME, MANCHESTER, ENGLAND

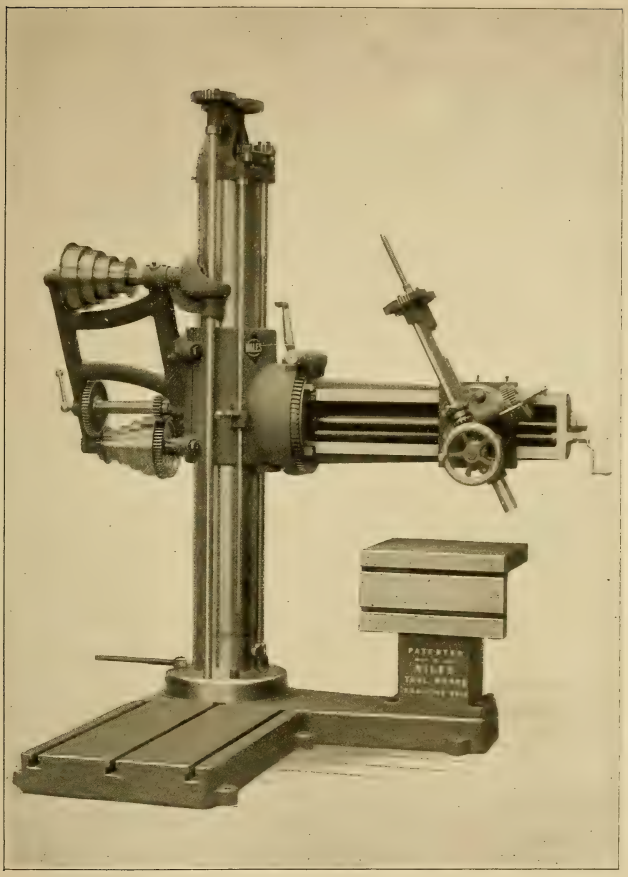


FIG. 23.—UNIVERSAL RADIAL DRILL MADE BY THE NILES TOOL WORKS CO., HAMILTON, OHIO, U. S. A.

of British manufacturers are keeping well to the front, and wherever this is the case they are more than holding their own.

Machine-cut toothed wheels are practically universal in the American machines, whilst until recent years they were the exception rather than the rule with British makers, excepting a few of the leading firms. Even now a good many British tool manufacturers limit the cut tooth to certain parts of the machine, and in some cases omit it altogether. The ball thrust, which is now coming into general use, was largely introduced by those firms who supplied the cycle trade with tools,—a trade, by the way, which has done not a little to prove the great value of the special tool,—and such tools are now being used by general engineers.

The American designer must be cred-

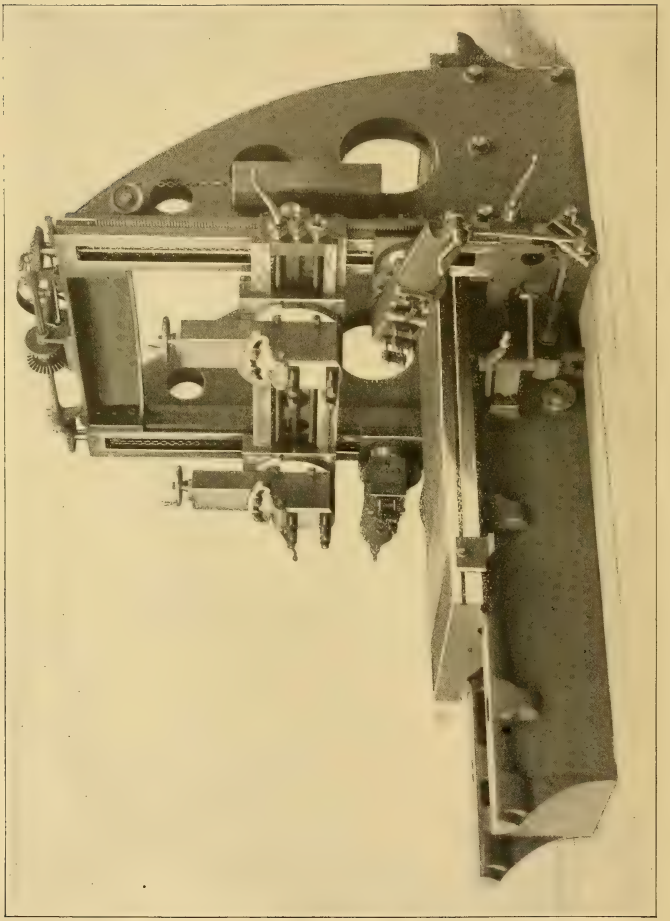


FIG. 25.—PLANER BUILT BY THE NILES TOOL WORKS CO., HAMILTON, OHIO.

ited with a number of very ingenious contrivances for changing of feed gears, as, for instance, that adopted in the Hendy-Norton lathe, shown in Fig. 29, and others, whereby differently pitched screws can be cut by the simple operation of shifting a handle in place of shifting several change wheels. Again, in milling and grinding machines, American designers have undoubtedly led the way in new developments, and have devoted an immense amount of attention to detail. While many of their contrivances may have originated in Great Britain, it has been left to Great Britain's competitors to elaborate and improve upon the original ideas, and to put them into practical shape on a large scale. It must not be forgotten that one sees the best American machines in Great Britain, and that there are poor American machines as well as good ones. Moreover, some American machines are not stiff enough for British work, and, as previously remarked, the iron used in the castings is frequently so soft as to rapidly wear away in the slides, etc.

British builders might with advantage devote more attention to some of the smaller details, such as the hardening of nuts, and other parts that have constant usage. Again, the substitution of fixed handles in place of nuts wherever possible is a great advantage. Building to gauge is now becoming a necessity if British makers are to compete successfully with those of the United States, and this is a feature largely absent with many British works. Such remarks will probably excite some criticism, since those makers who are well to the front and follow out the best ideas naturally

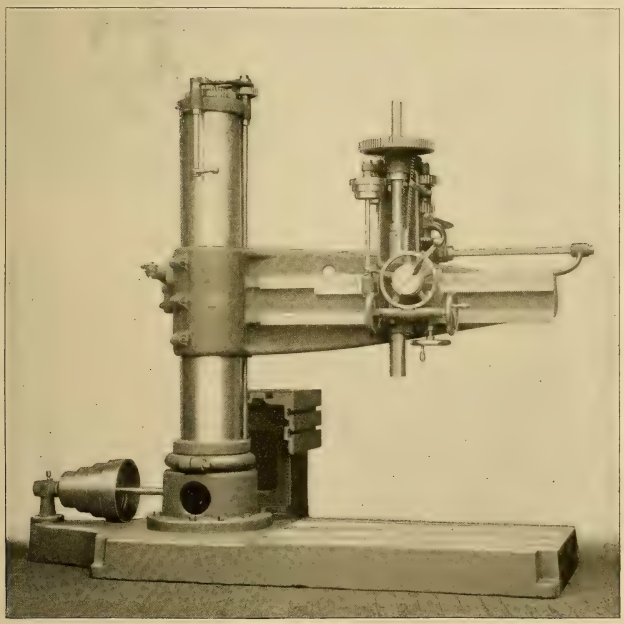


FIG. 24.—A RADIAL DRILL MADE BY THE BICKFORD DRILL & TOOL CO., CINCINNATI, OHIO, U. S. A.

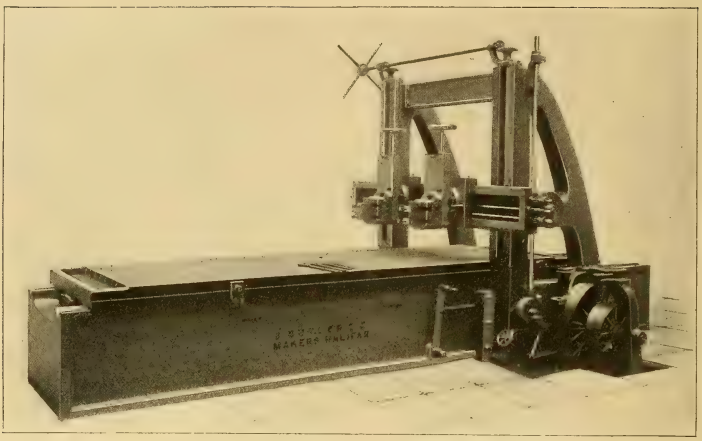


FIG. 27.—PLANER MADE BY MESSRS. J BUTLER & CO., HALIFAX, ENGLAND

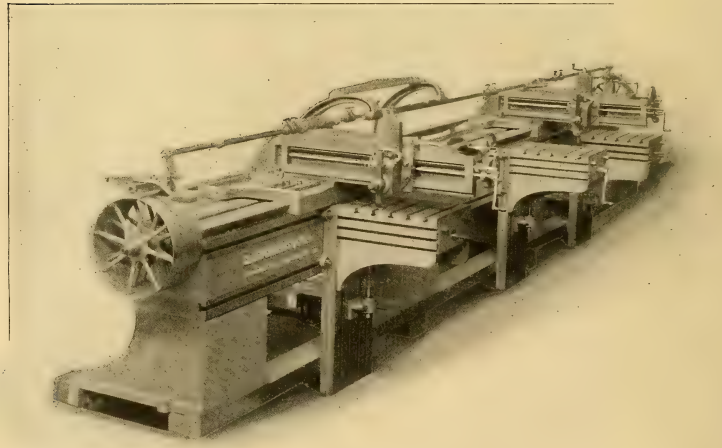


FIG. 28.—A SIDE PLANER WITH TWO ARMS AND THREE TABLES, BUILT BY MESSRS. GEO. RICHARDS & CO. BROADHEATH, MANCHESTER

resent the imputation of inefficiency, whilst the other makers who do not fulfill these requirements are apt to retort that they make a good, strong tool, which has so far met the demand, and they do not consider these points worthy of consideration. The user, however, is the person who will, and is, having something to say on the matter, and to those who have the opportunity of knowing the large amount of American machines which are being sold in Great Britain, it is evident that the purchaser recognises a good machine when he sees it. But it must not be supposed that it is because it is an American machine; far from it, because he will tell you that when he can get a British tool of the same capacity he buys it, and generally finds it more suited to his metal. Further, where British firms have combined the latest ideas with solid construction, their difficulty has been to deal with their orders. There are, indeed, many indications that the imported American tool is a blessing in disguise, and that as soon as British manufacturers start building the same design of tool, they will be able to stop the growing increase in the sales of the foreign machine.

While it is of the first importance to make a good machine, it is almost equally important to secure a ready market for it, especially in these days of keen competition. Americans have done not a little "missionary" work in this direction. Their method of carrying large stocks, and placing those stocks before likely purchasers by means of showrooms, has secured for them the greater part of their business, and has also educated British users in regard to the value of British specialties.

Then, again, the American system of representation is eminently superior to the British. Not only have the leading American firms agents in all the principal centres throughout Europe, but most of their representatives are experts in the machines they have to sell and

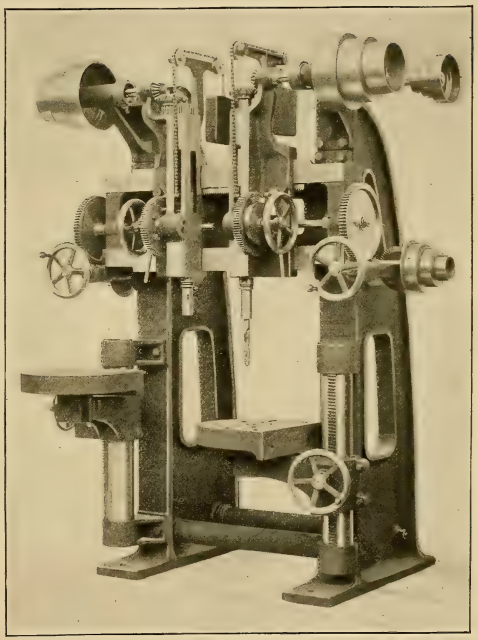


FIG. 26.—TWO-SPINDLE DRILL WITH INDEPENDENT HEADS AND TABLES, MADE BY MESSRS. WEBSTER & BENNETT, COVENTRY, ENGLAND

are well able to advise their clients as to their requirements. On the other hand, what do we find in regard to British manufacturers? Simply this, that they carry practically no stocks in London, and but little in the provinces, and that if they are represented at all it is simply by an agent with nothing more than an office, who in many cases, if not in most, is ignorant of what he is selling. It is true that some merchants carry British

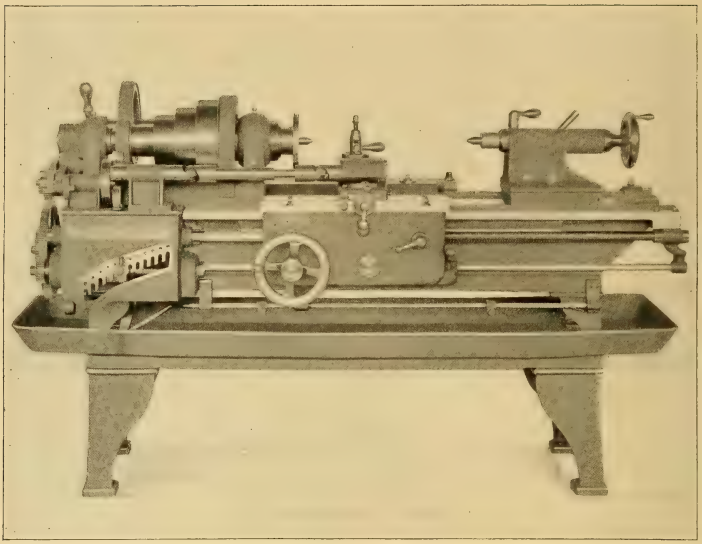
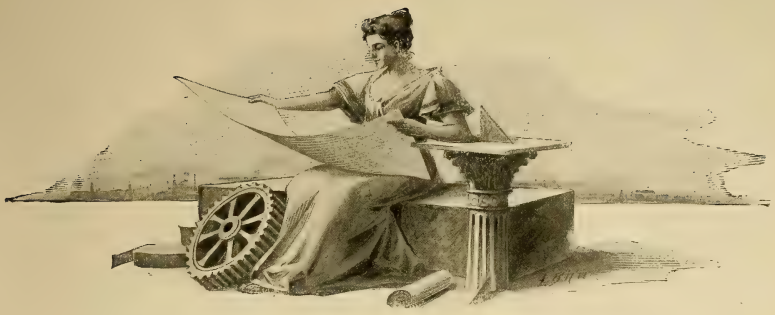


FIG. 29. A LATHE MADE BY THE HENDEY MACHINE CO., TORRINGTON, CONN., U. S. A.

stock, but during the last year or two there is great evidence that they are diminishing this and substituting American machines.

This is a growing and serious fact. And to this may be added another,—that several influential foreign firms, both American and German, have opened showrooms in London, and carry large and attractive stocks of the latest and most up-to-date machines in the market. These will doubtless be followed by similar showrooms in the provinces, and it is difficult to see when it will end. British manufacturers reply to all this that they do not think the great expense involved justifies the result (generally speaking, they have never given it a trial), and that they are so busy with tools for the government (many of which, it is to be feared, are somewhat obsolete) that they see no advantage to be gained. The recent abnormal demand for tools largely explains their want of enterprise, but with slack times the pinch will be felt as it has never been felt before.

Another point, and one often lost sight of, is that because British users have been satisfied with the antiquated class of machines hitherto put before them, is no indication that they will not appreciate better designs when these are brought to their notice. Users, as a rule, want to be advised as to the latest advances in machinery, and the American designer has made it his business to understand their requirements and to design a tool to meet them in a satisfactory manner.



Current Topics

Of the antiquity of the system of heating by means of hot water an interesting example is cited by Mr. Frederic Tudor in a diminutive treatise on "Heating for Health, or How to Heat a House," which he prepared about ten years ago. Mr. Tudor tells that the announcement of the discovery of Greenland by Davis, in 1587, brought to light the fact that the territory had been, centuries before, discovered and colonised by the Norwegians. The first European to land upon its shores was probably Leif, in the year 984, whose glowing accounts of its attractions led to the founding of a colony a year or two later. This flourished until, in the fourteenth century, it contained 190 villages, divided into twelve parishes with one bishop's see. Christianity had been introduced in the twelfth century, and a considerable intercourse was maintained with the mother country, Norway. The transfer of the latter to the crown of Denmark in 1387, its attachment to Sweden dating only from 1814, was the cause probably of neglect of the arctic colony, and eventually intercourse ceased altogether and the country and its people were forgotten. Doubtless there were occasional winters of great severity, and the inhabitants, languishing under the attacks of disease superadded to their hardships, perished without being able to make known their distressing condition.

Davis found no trace of any previous occupation of Greenland, nor in later years were the Eskimos able to give any definite information concerning them, although historians had discovered proof that Greenland had once been a flourishing colony. The latter were unremitting in their efforts to prevail upon the Danish Government to make a search for the lost colony, but it was not till 1723 that an expedition was undertaken with this object. It was in August of that year that Egede, in command of the expedition, and while seeking for traces of the lost colonists, came upon a group of remarkable ruins at a place called Kakortok, in Southwest Greenland. This has since been identified as Alba, which is spoken of by the ancient German author, Dithmar Blefken, who tells us that in 1516 he met a Dominican monk in Iceland who told him about the state of Greenland, and besides "several things about St Thomas' cloister, particularly that there

was a fountain of hot water which was conveyed by pipes into all their apartments, so that not only their sitting rooms, but also their sleeping chambers were warmed by it, and that in the same water meat might be boiled as soon as in a pot over the fire." This is also vouched for by Cæsar Longinus, in his "Extract of All Journies and Voyages." These old ruins, the earliest traces of Europeans in the Western hemisphere, were re-visited as recently as 1888 by the artist Bradford, who also found the hot-water spring which is of volcanic origin. This Mr. Tudor considers the first authentic example of the use of hot water for warming dwellings, though it probably was only a clever adaptation by the builders of the monastery of a method of conveying heat which must have been previously known to them. Mr. Tudor himself says that it is not improbable that the men who could build those magnificent cathedrals without mortgages were both able to appreciate the merits of hot-water heating and to make efficient use of it by the aid of appropriate apparatus. As to the utilisation, as above mentioned, of natural hot-water springs, it is not uninteresting to add here that piping such waters to houses has been practiced in more than one instance in recent years. In one old German town there is an installation of this kind going back beyond memory or record.

Reviewing marine engineering during the past ten years in a recent paper before the Institution of Mechanical Engineers, Mr. James McKechnie, engineering director of Messrs. Vickers, Sons & Maxim, Ltd., said that, so far as high-speed machinery is concerned, the now universal practice in the arrangement of engine cylinders is to fit a four-crank engine operated from four cylinders, usually on the three-stage compound system, and occasionally for quadruple expansion, the cylinders being arranged on the Yarrow-Schlick-Tweedy system. Ten years ago the greatest power developed in any steamer was 20,000 I. H. P., and the highest speed on an over-sea voyage 20.7 knots. Now, 30,000 I. H. P. is the highest in naval practice, the speed being 23 knots, while in merchant practice over 36,000 I. H. P. has been developed, the mean speed on a trans-Atlantic passage being 23.51 knots, while at the present time there is building a steamer to excel this splendid result. The low-pressure cylinder was only occasionally divided ten years ago, and the greatest diameter was 113 inches. In the case of the *Campania* such a division was made, and although the power was nearly 50 per cent. greater than in the ship with the 113-inch low-pressure cylinders, the diameter of the largest cylinders was only 98 inches. Experience has shown the enormous importance of balancing forces in the reduction of vibration, so that there has been a further encouragement to divide the third stage or fourth stage cylinders, always provided that tandem cylinders are arranged in couples to balance each other. In this way, even although the power has reached in one set of engines 18,000 I. H. P., the largest cylinder is only 106.3 inches, against the 113 inches in the 10,000 I. H. P. engine of ten years ago, the relative steam pressures being 220 pounds and 150 pounds. Larger diameters are certainly not desirable, but there is no reason why with higher steam pressure a larger number of expansions should not be adopted with multiple cylinders, because an increase in the number of cranks tends to decrease the vibration.

With increased steam pressure there has come a general increase in the average ratio of low-pressure to high-pressure cylinders. Ten years ago, when the steam pressure was about 158 pounds, the average ratios for twenty-eight triple-expansion engines were as follows: —

$\frac{\text{L.P.}}{\text{H.P.}}$	$\frac{\text{I.P.}}{\text{H.P.}}$	$\frac{\text{L.P.}}{\text{I.P.}}$
6.77	2.56	2.64

With an average working pressure of 180 pounds, the mean ratios for forty-

five triple-expansion engines built within the past year are:—

L.P.	I P.	L.P.
H.P	H.P.	I.P.
7.55	2.74	2 76

There is some variation in practice in the ratios of low pressure over high pressure, but the great majority of the cases are within one decimal point of the average,—7.55; but in the case of the other two cylinder ratios the variations from general practice are more marked. Generally in fast passenger steamers for the Channel service, where the runs are comparatively short, the conditions approximate to those in torpedo-boat destroyers, where reduction of weight is more desired than economy of fuel. And thus in the Channel steamers, with from 160 to 180 pounds boiler pressure the ratio of low pressure over high pressure is from 5.25 to 5.93. In steamers where coal economy is of importance, as is the case with large passenger liners and cargo boats generally, higher pressures have hardly brought proportionate change in ratio, the view accepted being that a large ratio of expansion is not necessary, or even helpful, to propulsive efficiency, when everything is considered, from fire-bars to propeller. With triple-expansion engines for cruisers there has been an increase consequent on higher steam pressure. In the earlier high-pressure cruisers using 210 pounds steam, the ratio of low pressure to high pressure was 5.6, whereas with 155 pounds steam in former ships with cylindrical boilers the ratio was 5. In later ships, with 250 pounds pressure, it has been increased to 7.1.

Turning to quadruple-expansion engines, the ratio of the low pressure to the high pressure ranges higher than in the case of merchant steamers with triple-expansion engines using the same steam pressure. In the case of twenty quadruple-expansion engines built recently the ratios are:—

L.P.	2d I.P.	1st I.P.
H.P.	H.P.	H.P.
10.23	4 40	1.96

It certainly would be useful to have an authoritative series of tests on this question, and on its bearing upon economy, but it is difficult, if not impossible, in ordinary sea working to approximate the same conditions in several similar ships, eliminating other variants in order to arrive at a definite conclusion on one such element.

According to the summary with which Mr. McKechnie concludes his above-mentioned paper, steam pressures have during the past ten years been increased in the merchant marine from 158 to 197 pounds per square inch, the maximum attained being 267 pounds per square inch, and 300 pounds in the naval service. The piston speed of mercantile machinery has gone up from 529 to 654 feet per minute, the maximum in merchant practice being about 900 feet, and in naval practice 960 feet for large engines and 1300 feet in torpedo-boat destroyers. Boilers also yield a greater power for a given surface, and thus the average power per ton of machinery has gone up from an average of 6 to about 7 I. H. P. per ton of machinery. The net result in respect of speed is that while ten years ago the highest sustained ocean speed was 20.7 knots, it is now 23.38 knots; the highest speed for large warships was 22 knots and is now 23 knots on trials of double the duration of those of ten years ago; the maximum speed attained by any craft was 25 knots, as compared with 36.581 knots now; while the number of ships of over 20 knots was eight in 1891, and is fifty-eight now. But probably the result of most importance, because affecting every type of ship from the tramp to the greyhound, is the reduction in the coal consumption. Ten years ago the rate for ocean voyages was 1.75 pounds per I. H. P. per hour; to-day in the most modern ships it is about 1.5 pounds. Ten years ago one ton of cargo was carried 100 miles for 10 pounds of coal, whereas now, with the great increase in the size of ships and other mechanical improve-

ments, the same work is done for about 4 pounds of coal,—a result which means a very great saving when applied to the immense fleet of over-sea carriers throughout the world.

Sawdust mortar,—a mixture of sawdust and lime,—has latterly been mentioned a number of times as a good covering for steam pipes, with the virtue thrown in of affording a means of utilising waste sawdust. Something like twenty years ago a covering of this general character, made up of sawdust and plaster of Paris, was used with satisfaction in one large steam plant, not only for steam pipes, but for the boilers as well; but the development since then of specially manufactured non-conducting coverings, in sections so as to permit easy removal and replacing should examination or repair of the covered-in parts become necessary, and at a cost about as low as that of the home-made product, long since led to the abandonment of the latter. It is doubtful, therefore, whether this sawdust mortar of more recent date is worth using except as a makeshift.

The latest and most important example of concrete construction in buildings is found in the case of one of the large railway companies whose shop buildings, with one exception, have concrete walls and foundations, and some of them also floors and roofs of the same composition. The general plan of construction was the usual one of pouring the concrete into moulds, built of tongued and grooved pine boards, special wooden frames being used where necessary. The buildings call to mind what was, in all probability, the earliest practical venture in this field, made by Mr. W. E. Ward about a quarter of a century ago, and described by him a short time thereafter in a paper read before the American Society of Mechanical Engineers. Mr. Ward's enterprise took the shape of a building for dwelling purposes in which not only the external and internal walls, cornices and towers were made of concrete, but all the beams, floors, and roofs as well, re-enforced with light iron beams and rods. Furthermore, all the closets, stairs, balconies, and porticos, with their supporting columns, were moulded from the same material. The only wood in the whole structure was in window sashes and doors, with their frames, and in the stair rails, thus excluding everything of a combustible nature from the main construction. Indeed, it was the desire for something of thoroughly fireproof character that seemed to have, to a great extent, inspired the undertaking. The exterior portions, too, of the house, which were more or less ornamental in their functions, were made of concrete in place during the progress of the work, and in the interior the cornices, ceiling, and wall panels and other details were of the same material, covered afterwards with the finish usual in such work. There were a number of other features about the house which helped to add to its interest, but the character of the structural material constituted its primary claim to attention.

One of the features to which allusion has just been made was the heating system adopted. In the centre of the cellar there was a heating chamber measuring 11 by 16 feet, and 8 feet in height. Within this chamber was placed an ordinary cast-iron heater with an extended, serpentine chimney flue connection, so as to get a large amount of heating-radiating surface for warming the air. Around the top of the walls of the chamber there were openings, about 12 inches apart, which led outwardly to spaces between the floors and ceilings, and also flues within the walls, these flues communicating with the spaces between the floors and ceilings of the second story. There were also vertical iron pipes so located as to connect the open spaces between the several floors and ceilings with a large closed trunk passage-way which ex-

tended nearly all around the inside of the main wall foundation, under the cellar floor, and which led directly under and into the heating chamber. The method of operation of the system consisted simply in the body of warmed air passing from the heating chamber upward, through the walls and under the floors, and in its passage giving up its surplus heat to the surfaces of these flues. As the air became reduced in temperature it naturally descended through the iron pipes and trunk flue provided for its return to the heating chamber, where it was again charged with heat. A continuous circulation of the same air was thus effected, and the performance of the system was, as might have been expected, a most satisfactory one.

WIRE-WOUND cast-iron water pipe is the latest of the several wire-wound specialties, if it be permissible to thus term wire-wound guns, wire-wound flywheels, copper steam pipes, and wooden-stave water pipe. It appears to be a French innovation, being credited to the managing director of the Société Metallurgique d'Aubrives et Villerupt, the steel wire being bedded in grooves cast in the body of the pipe, and the ends being secured by pouring molten tin over them. An asphalt coating completes the job. Trials with pipes thus fortified are said to have given excellent results, and a large water main on this principle is stated to have been put down in Paris.

A NOTEWORTHY feature of some of the large steel engine shafts and even minor forgings of recent years is that they are hollow. They have other features also which are as characteristic and yet not so apparent. These are so peculiar to modern methods of manufacture and are so little appreciated that a few words in explanation, recently given by Mr. H. F. J. Porter, of the Bethlehem Steel Company, in a paper before the New England Cotton Manufacturers' Association, appear pertinent. Beginning with the primary operation, Mr. Porter took up first the casting of the steel ingot. In making up the charge to be melted for the production of the casting from which the subsequent forging is to be made, the composition of the various raw materials must be considered. These raw materials, such as iron ore, scrap iron, etc., have various elements in their composition, especially carbon, silicon, manganese, phosphorous, and sulphur, each of which affects the strength of the resultant product. So also must the amount of material be carefully estimated. Remembering that the casting must be reduced in size in the forging process, 50 per cent. at least must be added to the area of section of the initial casting, over and above that of the finished forging. In addition, 25 per cent. must be added to the length for reasons which will be made apparent. Having properly charged the furnace with the requisite quantity of materials of the right composition, and heated the charge until it has melted, a small dipperful of the fluid is withdrawn and tested to observe if the mixture is proving itself to be according to calculation. Such additional ingredients as are required are put in as occasion may demand, and when the charge is satisfactory it is run into a ladle and from it is poured into the mould. In the pouring process air is apt to be entrained which may cause "blow holes," and in the process of cooling gases are sometimes generated which may cause the same kind of defect, or possibly only spongy spots. Such occurrences must be avoided at the outset by taking proper precautions, for as steel does not weld satisfactorily, these defects cannot be eliminated as its manufacture progresses, and are, in fact, greatly aggravated.

MANY methods have been devised to secure freedom from these imperfections, but the most satisfactory of them all is the so-called Whitworth process of fluid-compression, in which the metal in the mould is subjected, while in the

molten state, to a pressure running up to 7000 tons, and this pressure is continued until the mass is cold. This process also tends to avoid another serious defect known as segregation. As each of the various elements above mentioned solidifies at a different temperature, there is a tendency in them to separate from one another and to seek in the molten liquid their proper location according to their respective specific gravities. The effect of this action, which is partly chemical and partly mechanical, is to draw them towards the centre and top of the mould where cooling takes place last. This tendency is checked, however, under the great pressure to which the fluid mass is subjected by the process just mentioned.

"PIPING" is a term applied to another defect that is apt to occur in large ingots. When the mould is filled with molten metal that part which is located at the surface of the mould cooling first solidifies there, and as the cooling process continues, forms a gradually contracting vessel filled with liquid steel. When the whole mass has cooled, it is found that there is a "pipe" or hole running down through the centre of the ingot, which is due to the combined contraction of the mass during the cooling process. The fluid compression, by forcing the hot metal down from the top of the ingot, which cools last, tends to fill this pipe, and thus produces a solid mass of steel. When the ingot has solidified it is removed from the mould and allowed to cool, care being taken that the rate of cooling is not so rapid as to contract the surface of the metal on to that in the centre and thus cause exterior cracks. The upper part of the ingot which has supplied metal under pressure to fill the "pipe," and has, in addition, served to collect the surplus segregated elements, is not considered suitable for forging purposes, and is, therefore, cut off and discarded. This will explain the addition of the 25 per cent. added to the length of the ingot as originally designed.

THE tendency in steel ingots to have an imperfect core or centre led initially to the removal of the defective material from that portion of the forging by boring, and thus hollow shafts were first brought into service. The boring of a shaft necessarily weakens it, however, by so much strength as is possessed by the metal removed. It was only when hydraulic presses were introduced as forging tools that so-called "hollow forging" became practicable. In this process, after the ingot has been bored it is heated slowly and carefully, so as not to subject the metal to the danger of cracking from too rapid expansion. A mandrel is then inserted through the axial hole, and the ingot, with the mandrel in its centre, is brought under the hydraulic press and worked by slow and repeated pressure until it assumes the desired shape and size. Thus the mandrel acts as an internal anvil, and enables the press men to thoroughly work the thin walls of the hollow shaft and to allow the flow of the molecules of the metal throughout the whole mass to take place slowly and completely.

SUBMARINE torpedo-boats have, during the past year, received so much governmental attention in Great Britain, France, and the United States that the failure, during the late Spanish-American war, to put the Holland boat, or some other type, to practical test at Santiago Harbour, for example, seems more than ever like a badly wasted opportunity. Finding its way about when under water is the one great difficulty with which the submarine craft now has to contend, and until that part of the problem of submarine navigation has been more satisfactorily disposed of, the full virtues of under-water fighting will not be realised. Semi-submergence of the boats is the best that can be counted upon at present.

One form of town refuse disposal of which particulars were recently given in a consular report from Leipsic, Germany, is its conversion into fuel briquettes,—a French process, it is said. As described, it provides for mincing the refuse from abattoirs, fish markets, etc., straw, paper, and the like, and adding tar and naphthalene. The whole mass is then mixed in a kneading apparatus, dried, and pressed into briquettes, for which all the virtues of ordinary coal are claimed. Another species of briquetting process, of American origin, is to be applied to hay, straw, cornstalks, and similar combustible refuse, so that these may be used as fuel on the western American plains, where wood and coal alike are scarce and costly. The proposition, according to several accounts, is to turn out the compressed material in the shape of round sticks, 9 to 12 inches in diameter, and 2, 4, and 6 feet in length. The material will be as hard as wood, and will last longer and make a better heat than soft coal. Weeds may be used as well as straw, and the cost of making the fuel will, it is added, be much less than the present cost per ton of coal.

JOHN CHRISTIAN KAFER

A BIOGRAPHICAL SKETCH

By William Ledyard Cathcart

The American Civil War was a titanic struggle, which, in the methods and magnitude of its action, was as unprecedented in history as its results were epoch-making in ending the bondage of the slave and in establishing the unity of a nation, divided from the hour of its birth. In no respect was this prolonged conflict more remarkable than in the extent and unexampled character of the work demanded from the fleet. The Hon. Hilary A. Herbert, ex-Secretary of the United States Navy, and a former officer of the Confederate Army, has said that the two operations which were the main factors in producing the fall of the South were the blockade which slowly starved the Confederacy to death and Farragut's control of the Mississippi River which parted its territory in two. The unceasing patrol of stormy seas and the hard fighting on inland waters, which led to these results, were the work of the Navy wholly.

In no great war were the duties of the fleet more fundamental or more novel. For close action against fortifications and to meet the heavy ironclads which the South, with almost superhuman effort, sent forth, armoured vessels, such as the low-lying monitors and the superb frigate *New Ironsides*, were required. To maintain a blockade approaching effectiveness along the widely extended Southern shore, with its intricate passages and shallow waters, there was needed a swarm of steamers, swift, seaworthy, and of light draught. To pursue commerce destroyers on the open ocean, only large vessels of extreme speed would serve; and, in the support of the army, on the inland rivers where many a salt-water sailor met death, shallow steamers, with great battery power and of the utmost handiness, were necessary. To meet these varied demands the national government had, in the beginning, but ninety vessels, fifty of which were sailing ships. Of the steamers, only about twenty-four were, at that time, effective, and of these but three were in Northern harbours. Through the deliberate inaction,

or worse, of the preceding administration, the remainder were scattered on many seas.

The magnitude and diversity of the prospective fleet, however, indicate but in outline the herculean task which confronted the Navy Department. Owing to the parsimony of Congress, governmental apathy, and that conservatism which is the besetting sin of navies, little was known in the United States, even experimentally, of the very elements of the ships which were to be constructed. Take the question of propelling power, for example! There were to be four years of fighting under steam, and yet 55 per cent. of the force afloat were sailing ships, and the fact that the latter were obsolete for war purposes was by no means generally admitted. Indeed, the prejudice against steam power lingered long after among the Bourbons of the service. As late as 1871, we find the admiral of the navy defending the inefficient two-bladed screw on the ground that the four-bladed propeller was "unfit for a ship manœuvering under sail." The smouldering embers of this dislike for, and ignorance of, steam, glowed again fatefully off Santiago, when our fleet lay, largely under reduced boiler power, awaiting the sortie of the Spanish squadron. Had Cervera's dash been made with his vessels moving at their designed speed, the story of the fight would probably have differed widely from that mutely told to-day by the fire-scarred hulks stranded on the Cuban coast.

With regard to armour, the situation in 1861 was still worse. During the war of 1812 that most accomplished engineer, John Stevens, had submitted to the government the first practical design in modern naval annals for the use of armour afloat. For a generation thereafter members of his family continued his work with regard to armour, in a long series of experiments of much value; and, through their efforts, the building of the Stevens ironclad battery had been begun, but, owing to the niggardliness of Congress, only to be abandoned in 1855. Meanwhile, the subject had been studied in Europe, and, as a result, French armoured batteries in 1855 had silenced the Kinburn forts, in the Crimea. In 1858 the French laid the keel of the ironclad *La Gloire*, and that vessel was followed at once in Great Britain by the armoured frigate *Warrior* and ships of her class.

Yet, despite the practical birth of armour in the United States and the progress made abroad from 1855 onward, the United States Board on Ironclad Vessels, in its report of September 16, 1861, gravely included, though it did not endorse, the statement that,— "It has been suggested that the most ready mode of obtaining an ironclad ship of war would be to contract with responsible parties in Great Britain for its complete construction." It required the personal intervention of Abraham Lincoln and Gideon Welles to induce this able, but prejudiced, board, consisting of two commodores and one commander, to recommend the building of the *Monitor*, and in the contract for the latter, as finally signed, the remarkable views of the Secretary's naval advisers are shown by the clause requiring the builders to furnish "masts, spars, sails, and rigging of sufficient dimensions to drive the vessel at the rate of six knots per hour in a fair wind." The *Monitor* finally went to sea in March, 1862, with a turret built up of eight layers of 1-inch iron plates, since even the *Warrior's* plating of 4½-inch rolled iron was unobtainable in this country.

The board above referred to reported, with regard to ordnance, that "as yet, we know of nothing superior to the large and heavy spherical shot in its destructive effect on vessels, whether plated or not. Rifled guns have greater range, but the conical shot does not produce the destructive effect of spherical shot." With this statement should be contrasted the fact that the French had some cast-iron rifles afloat during the Crimean war; that, by 1859, that government was "thoroughly committed to the rifled gun as the standard for heavy artillery," and that the trials of 1858-59 in Great Britain had resulted in the adoption of the Armstrong rifle

for the British Navy. It is true that, through the genius of Dahlgren, the United States fleet was provided with a most excellent smooth-bore gun; but so little were its capabilities understood that those of 11-inch bore on the *Monitor*, in her one great action, were served with but fifteen pounds of powder, while they would have withstood readily a thirty-pound charge. As a result, the *Merrimac's* armour was practically uninjured, and there was a drawn fight, instead of the complete victory which the *Monitor's* battery, properly handled, would have won.

As to the minor mechanisms of naval war,—the ram, the torpedo, and the partially submerged torpedo-boat,—the United States fleet was to learn, by bitter experience, something of all. The torpedo, like armour, was of American conception; it had shown its deadliness in the Crimean war, but Quixotic sentiment had prevented its study and adoption in the land of its birth. Even Farragut, as late as May, 1864, wrote:—"I have always deemed it (the torpedo) unworthy of a chivalrous nation."

To grapple with naval unpreparedness, there was not only at the helm of the navy a brilliant and most masterful secretary in Gideon Welles, but he was provided, as well, in the bureau system of his department, with an administrative staff whose work was capable of very large expansion without friction or confusion. By December 1, 1861, seventy-nine steamers and a number of sailing transports had been purchased, and at the close of that year there were afloat 20,000 men and 2300 guns. Many ironclads of varying types were built on the Eastern coast and Western rivers; the Parrott rifle was developed until, in 1862, it was the most powerful gun of its weight and calibre afloat; twin screws were introduced, and the speed of steamers was increased, reaching a climax in the cruiser *Wampanoag*, whose phenomenal run at sea remained, for ten years, unequalled by liner or by warship; and, at the close of the war, the naval list showed a total of about 670 vessels, of 510,000 tons, carrying 4600 guns and 51,000 officers and men. The world had seen a tremendous development in naval science and strength in the conflict between a national government having, at first, but the shadow of a fleet, and revolted States which were, in the beginning, almost wholly without ships or the means of creating them. Lincoln, in his last annual message, might well take pride in the fact that "a navy of such vast proportions has been organised in so brief a period and conducted with so much efficiency and success."

In looking backward through those years the student of naval progress cannot but conclude that the first shot fired at Sumter marked an era in naval history; that it rang the knell of the old order on the sea. In the transformation and revolution which were at hand the engineer was to appear as a factor in every essential detail of the warship's construction and management as, day by day, the need grew for iron hulls, iron armour, rifled guns, intricate torpedo mechanisms, engines of steadily increasing power, and the application of steam to many varied purposes on shipboard. In view of these conditions, it was but natural that many able and talented young men turned, in their desire to serve the government, toward the Engineer Corps of the Navy. That corps, at the beginning of the war, was composed of 194 men, who, under the rigid system of examination which had prevailed for years, formed a body of highly trained, technical officers, which had once been headed by that kindly nestor of engineering, Charles H. Haswell, and which then numbered in its ranks men like Isherwood and Loring, known not only for executive ability, afloat and ashore, but for achievement in scientific research. On January 1, 1865, the Navy Register showed the great expansion in the ranks of the Engineer Corps which the needs of the fleet in war service made imperative, there being, on that date 474 engineer officers of the regular navy and 1803 volunteer engineers. Among the young men whose patriotism, scientific training, and engineering instinct thus turned them to the sea, there were not

a few who, in later years, won high rank in their profession, as George W. Melville, George Westinghouse, Charles E. Emery, Robert H. Thurston, E. D. Leavitt, Theodore Cooper, and John C. Kafer, the subject of this sketch.

Mr. Kafer is of German ancestry, coming from a family which, about the year 1825, left the Palatinate for the United States. He was born December 27, 1842, in Trenton, N. J., in which city, also, his early years were passed, his education being obtained at the Trenton Academy and other schools. His father's partner in several business enterprises was John G. Stevens, of the famous family of engineers, who was, at one time, resident engineer of the Delaware & Raritan Canal Company, and, later, president of the United Railroad Companies of New Jersey. Mr. Stevens showed a warm interest in the lad's engineering development, and, through his advice, young Kafer was, upon his graduation, placed with the firm of Gillingham, Golding & Co., of Trenton, in whose draughting rooms and shops he received a thorough training on both theoretical and practical lines. The outbreak of the Civil War found him thus engaged.

On January 16, 1863, twenty days after he had reached the age required by law, Mr. Kafer was appointed a Third Assistant Engineer in the regular navy, and was ordered at once to the U. S. S. *Ticonderoga*, which vessel cruised for some months in the West Indies in search of the commerce destroyer *Alabama*. From Cape Haytien, Kafer, suffering with both fever and rheumatism, was invalided home. In January, 1864, he was ordered to the U. S. S. *Mackinaw*, then at Baltimore. After a series of experiments to determine practically the economy of steam at varying rates of expansion, this vessel joined, at Hampton Roads, the squadron under Rear Admiral S. P. Lee, and, later, led the advance in the expedition up the James River, in which land forces under General B. F. Butler co-operated. The *Mackinaw* remained up the James until, in July, 1864, she was sent to Washington, where Kafer, again ill, was granted sick leave.

Life, during the anchorage in the James, was not monotonous. The Confederates had not only planted mines in the river, but also displayed much energy and ingenuity in floating down contact-torpedoes. The *Commodore Jones*, a Union vessel, was blown up almost alongside the *Mackinaw*, and several torpedoes, at various times, became attached to the hawser securing the latter. These were removed and examined by Kafer, who found the construction to be both simple and deadly. The torpedo was a plain cylinder of tin containing a powder charge; through the cap projected several wire rods which, when forced inward by contact with any obstruction, would explode the charge; a stuffing box, packed with beeswax, encircled the rods. In addition to the possibility of destruction by torpedoes, there was, ever present, the danger of an attack from shore, in preparation for which all hands were called to general quarters an hour before daylight every morning. Occasional surprises, in rifle-cracks and the scream of bullets, showed the wisdom of this precaution. When General Grant's forces crossed the river on pontoons, the *Mackinaw* was detailed to protect the troops during the passage.

Kafer's next duty was on the frigate *Minnesota*, which, in December, 1864, left Hampton Roads with the great fleet assembled under the command of Rear Admiral David D. Porter for the first attack on Fort Fisher. In this memorable action thirty-seven United States war vessels took part, the bombardment being so heavy and sustained that, during the two days of its continuance, the frigate *Colorado* alone fired about 2800 heavy shot and shell. The *Minnesota* was the first large vessel to take position, as close to the shore as possible, with but little water under her keel. The withdrawal of the land forces under General Butler, the failure of the attack, and, in consequence, the life-long controversy between Porter and Butler, are matters of history.

On January 13-15, 1865, Porter, with

forty-four war vessels, co-operated with General Terry's force of 10,000 troops in a second and successful assault on the fort. On this occasion volunteers were called for from the fleet to "board the fort in a seamanlike manner." Some of the engine-room force of the *Minnesota* answered this call, and asked that one of their own officers go with them, which Kafer volunteered to do. On the morning of the attack, however, as the landing party, with Kafer and his men, were dropping into the boats, he was ordered to duty on board ship This change probably saved his life, since the naval brigade landed on a sand beach, without shelter from the enemy's fire, and, in a total force of 1400, lost 309 men, 74 being killed outright, among them Assistant Surgeon Longshaw, the only other volunteer officer from the *Minnesota.*

On April 15, 1865, the morning of President Lincoln's death, Kafer sailed for the Mediterranean in the sloop-of-war *Kearsarge*, one of the famous ships of the old navy. Her executive officer was Lieutenant-Commander George Dewey, who was destined, a generation later, to make history for the nation in Manila Bay. The summer was spent on the coasts of France and Holland, the winter in the Mediterranean, and, early in 1866, the ship was ordered to the west coast of Africa. Here, after leaving Sierra Leoné, yellow fever, in an acute form, appeared on board, causing fourteen deaths, among them that of the ship's only surgeon, Dr. Benjamin Vreeland. He and Kafer had been warm friends, and, when stricken, he sent for Kafer to say,—"I can do nothing more. Read 'Bartlett on Fevers,' and do the best you can to save life here."

The care of the health of a ship's company, under such conditions, was not a light task for a young engineer officer. However, the cases required no diagnosis, and Kafer manfully took up his burden, treating each patient "by the book," and dealing out, with a liberal hand, the most heroic remedies. The day before Vreeland died Kafer was giving him a hot mustard bath, when the doctor breathed in his face, and, in a moment, Kafer realised that he himself was in the fever's grip. The attack proved to be severe; but, through warm baths and generous doses, as laid down by Bartlett, the gallant engineer officer was able to pull through.

After the return of the *Kearsarge* to the United States, Kafer was granted leave of absence for a brief period, and then served, during 1867-8, on the flagship *Susquehanna*, of the North Atlantic squadron. The first duty of this vessel was diplomatic, in conveying Minister Campbell and General William T. Sherman to Mexico. The officers of the ship were ordered, by telegraph, to report on board, and the greatest energy was shown in getting her to sea; but, once beyond Sandy Hook, the need for urgency seemed to have disappeared. The ship proceeded in leisurely fashion, made a stay of considerable duration at Havana, and, when she finally reached Vera Cruz, Sherman did not disembark, returning to the United States without having set foot in Mexico. Long after, when they cruised together on the *Despatch*, the general told Kafer the real meaning of that mission. William H. Seward desired to have General Grant ordered to Mexico while the Emperor Maximilian was there, in the hope that the general would, in some way, so commit himself as to be unavailable as a candidate for the presidency. Sherman heard of the scheme, saw the President, and offered to go in Grant's stead. President Johnson, however, announced his intention to order Grant on the mission.

"He will not go," said Sherman. "Then I shall have him court martialled," was the President's answer. "You cannot do that, Mr. President," said the general, "the people of the United States will not permit it." In the end, Sherman won, and went smilingly to sea on an errand which was, for him, without an object.

The most eventful incident in the cruise of the *Susquehanna* was her experience in the harbour of St. Thomas, which port she reached just after a hur-

ricane had passed over the island. On the Monday after her arrival there was an earthquake, followed by a tidal wave. The ship was, at first, lifted and dropped as if she were on the rocks; a wall of water, 30 feet high, came in from seaward, swept over many small craft, twisted the iron pier as if it were made of wire, and dragged the 3800-ton *Susquehanna*, with her two 7000-pound anchors, about the harbour as if she were a yawl. The same wave carried the U. S. Sloop-of war *Monongahela*, 2200 tons, ashore at Santa Cruz and landed her, high and dry, before the hotel. After the earthquake, yellow fever appeared on the *Susquehanna*, and, owing to the death of the admiral and a number of officers and men, the ship was ordered to New York and put out of commission.

During 1875-8 Kafer served on the Asiatic station in the flagship *Tennessse*, and, during 1882-5, on the U. S. S. *Despatch*, which was then used as the President's yacht. His duty on the latter vessel closed his active service at sea. While on the *Tennessee*, one of Kafer's fellow officers was Charles H. Loring, then fleet engineer of the Asiatic station, and another was George W. Melville, then a passed assistant engineer. Both were destined to win the highest honours given officers of their corps, the former being appointed engineer-in-chief, with the rank of commodore, in 1884, and serving until 1888; the latter succeeding him in office and, later, by the provisions of the Personnel Law, being promoted from the grade of commodore to that of rear admiral. It is safe to say that, in the long history of the Engineer Corps, there can be found no two of its chiefs who are the equal of these officers in distinguished service and in the regard with which they are held by the Navy and by their countrymen.

During Commodore Loring's term as engineer-in-chief Mr. Kafer became his principal assistant, effectively supporting him in his advocacy of the most advanced progress in the plans of new vessels at a time when such advocacy, with regard to American designs especially, met bitter opposition. Of his service with Mr. Kafer, then and earlier, the commodore says:—

" I have been associated with Kafer, through several tours of duty ashore and afloat, to my great pleasure and advantage. He has shown himself fully equal to any emergency, and capable of coping successfully with every problem submitted to him. He has superb executive ability, a fruitfulness of resource in all professional work, a happy manner in the treatment of the affairs of daily life, the tenderness and gentleness of a good woman in personal intercourse, and, dominating these attributes, an intellectual faculty always in perfect poise, whatever the disturbing influence."

When Admiral Melville entered upon the duties of his office as engineer-in-chief, Mr. Kafer was, at his request, ordered as the admiral's principal assistant and adviser, having previously served with Melville, while the latter was stationed at Philadelphia, in the preparation of the plans for the *San Francisco*. His detail to the latter duty was strenuously opposed by the, then, chief of the Bureau of Navigation; but the matter was urged so vigorously before the Secretary by Melville that the former had the orders issued, although Kafer was at the time on sick leave, and could have declined the duty. Mr. Kafer was thus one of the principal workers in laying the foundations of the new navy; and his retirement from the active list, enforced by ill health in 1888, was a loss of moment to the progress of that work. Melville, in characteristically cordial words, writes thus of Kafer's service to him and to the fleet:—

" When on the good ship *Tennessee*, we were both comparatively young men, full of life and vigour, and naturally grew fond of each other. I have found Kafer one of the most kindly and genial of men, yet of a most forceful and judicial character, and always to the fore in defending his bill of rights under the law. His methods, in his profession, are scientific and accurate to a marked degree. When I was called to write my opinion of his pro-

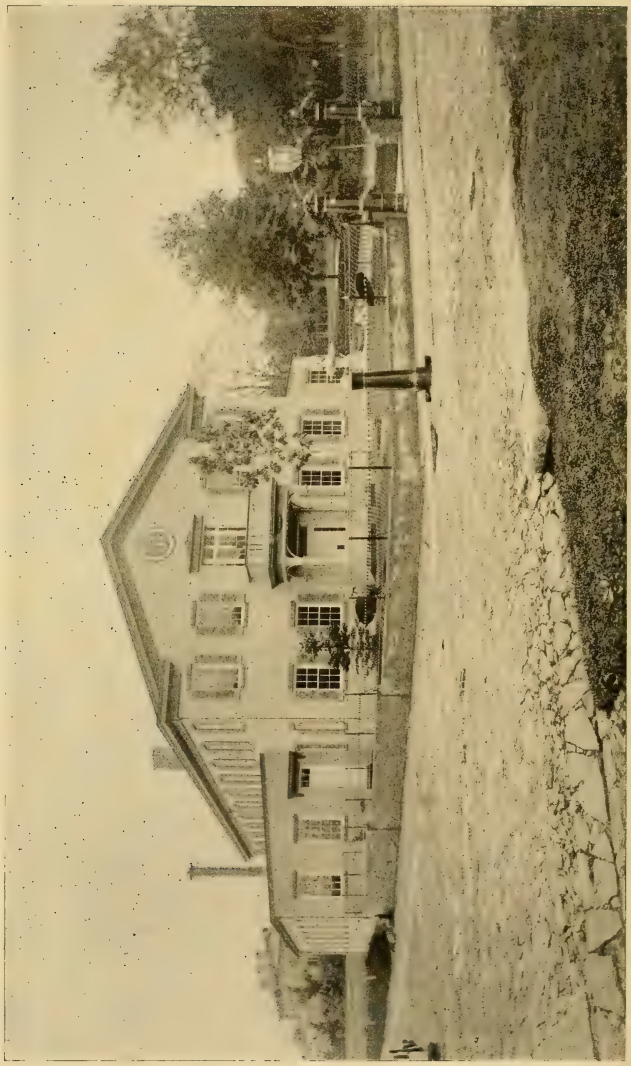
fessional qualifications to the Secretary of the Navy, I stated that, for his years of service, I knew no better engineer than he; and now, after these many years, as shipmate, friend, and adviser in times gone by, I find that my opinion and affection have remained, from the first, unchanged."

The opposition, noted above, to the issuance of Kafer's orders to Philadelphia was an unintentional tribute to him. He was then on sick leave, and it was the desire of a, happily but small, faction of naval officers that he should remain thus inactive and innocuous to their interests. Kafer, however, it appears would not long "stay dead." The explanation of this opposition lay in the fact that, from his entry into the service, he had upheld constantly the dignity of his corps and had been a strong advocate of the proper recognition of engineering in the navy. Until the passage of the Personnel Act of March 3, 1899, the laws governing the rank and privilege of the staff of the navy, while not intentionally unjust, were drawn, to a certain extent, loosely, thus opening the way for severe, and sometimes unfair, regulations, and leaving broad ground for controversy.

Kafer could not be brought to see that engineering should hold a place second to that of any other profession; and, as a consequence, wherever there was, in point of law, standing room in this subject, it was fairly certain that, at one time or another, John Kafer would be found occupying it, in forceful, but courteous, argument for the rights of his corps. His consistent adherence, for a score of years, to this policy was naturally somewhat irritating to gentlemen who held extreme views on the opposite side; and to this relatively small faction he was known, in the somewhat harsh language of those contentious years, as a "trouble-breeder." The warfare, however, was, with him, impersonal. It is written that "Satan is an accuser of the brethren," but his majesty's methods were not Kafer's. His arguments were aimed, not against individuals, but at a just construction of law and regulation, and he found it possible to meet genially, on social ground, fair-minded men who might be, for the time, his official antagonists. As a result, he won the respect of the latter, and, in not a few instances, their warm friendship.

A noteworthy incident in Mr. Kafer's naval career was his successful leadership in the movement which, after years of effort, resulted in the passage of the Act of Congress, approved March 3, 1885, giving "longevity," or increased, pay to passed assistant engineers for their third and fourth five-year periods of service in that grade. The law originally assumed that promotion to the grade of chief engineer would occur at, or within, ten years as passed assistant engineer, and, therefore, provided longevity increase of pay only for the first and second five-year periods of service in the latter grade. Owing, however, to the restricted numbers of the Engineer Corps and the fact that many of the chief and passed assistant engineers were about the same age, stagnation in promotion was inevitable, and it was clear that many of the latter officers would remain from fifteen to twenty years in the lower grade and a few would arrive at the age for retirement before promotion could reach them. Remedial legislation, as above, was secured only after ten years of effort. It is pleasant to note that the measure received the strong support of the Military Order of the Loyal Legion and the Grand Army of the Republic, since the officers who would benefit by the Act were veterans of the Civil War. Of Mr. Kafer's action in the matter, an able officer, long associated with him, says:—

"His long and up-hill fight for this measure, his winning over every obstacle, his persistent effort, all showed him as a man among men; and the successful passage of this Act, despite powerful, adverse influence, was due to him. Others aided in the work, but the skillful management, the keen watchfulness, and the ultimate success belonged to him alone."



THE STEAM ENGINEERING BUILDING AT THE UNITED STATES NAVAL ACADEMY AT ANNAPOLIS, IN 1878

In his annual report for 1863, Gideon Welles said:—

"It is a question, indeed, as sails are subordinate to steam, whether every officer of the line ought not to be educated to, and capable of performing, the duties which devolve upon engineers. * * * * If the public is not yet prepared to combine what at present are two distinct pursuits and make every naval officer an engineer as well as a sailor, I would recommend the formation of a class at the Naval Academy of youths, giving a preference to those who may have already evinced mechanical skill and aptitude for engineering, who might be educated with special reference to their profession as engineers."

Again, in 1864, he wrote:—

"The remedy for all this is very simple, provided the principle were once recognised and adopted of making our officers engine-drivers as well as sailors. It would not be expedient to interfere with the present status of line officers or engineers,—the change would be too radical; but we should begin by teaching each midshipman to be able to discharge the duties of line officers and engineers, to combine the two in one profession, so that officers so educated can take their watch alternately in the engine room and on deck."

It is a striking tribute to the genius and prescience of Secretary Welles that, a generation after he wrote these words, the plan which he outlined should be carried, in all essentials, to a successful issue through the wisdom and energy of Secretary Long and the then Assistant Secretary, Theodore Roosevelt.

The project of the great war secretary was, however, thirty years and more in advance of his time. Before the final amalgamation of 1899 was to occur his alternative plan of 1863 was to be adopted; a curriculum for engineer officers was to be established at the Naval Academy, and the standard of instruction for the cadets of the Engineer Corps was, through various vicissitudes, to rise so high as, in the end, to meet abolition because of its very success. In 1865 the Department of Steam Engineering, with a staff of engineer officers, was established at Annapolis; in 1866-7 four cadet engineers, and in 1866 sixteen acting third assistant engineers were admitted to the course. For a time, through opposition and indifference, there was no progress; but in 1871 the course was revived,—sixteen cadets being admitted,—and endured, in steadily growing excellence and vigour, until, in 1882, it was abolished by Act of Congress, and its cadets were transferred to the line of the navy. The elements of the success which wrought its ruin were the unusual ability and fidelity of its instructing staff; the fact that the examinations for admission were competitive, with, frequently, ten applications for each vacancy; and the further fact that so keen a competition could be met only by difficult entrance examinations,—a test which provided a most thorough system of selection.

In the success of this course Kafer figured most prominently. During his two tours of duty at the Naval Academy, from 1868 to 1874 and from 1878 to 1882, eleven classes of cadet engineers,—all but one of the whole number,—were trained in their profession. His associates, themselves men of high attainments, are frank and unselfish in their recognition of Kafer's leadership. Mr. Charles H. Manning, who was a fellow instructor for eight years, who was, later, a member of the first Advisory Board convened to report on types of vessels for the new navy, and who is now one of the foremost mechanical engineers in this country, says:—

"It was largely due to Kafer's energy that the law authorising the instruction of cadet engineers was revived and put in force in the fall of 1871. Furthermore, he had more to do than any other with the arrangement of the course of study, and the results obtained in the few years that this law was allowed to live are sufficient evidence of his ability and skill. In the literature of engineering Kafer is one of the best informed men I have ever known, as well as one of the most capable advisers in difficult

and delicate details of administration." Again, Chief Engineer David P. Jones, U. S. N., retired, the gallant officer who made a night journey of grave danger up the James to City Point, as the bearer of despatches to General Grant, announcing the fall of Fort Fisher, and who was, for five years, stationed at Annapolis, says:—

"With other instructors, I early learned to regard Kafer as a walking encyclopædia of engineering knowledge. To him the old naval Engineer Corps owed much, in addition to his notable work at the Naval Academy. As an instance of his quick perception and thorough knowledge, I recall the reading, before a professional society, of a prize essay on 'The Best Type of Armed Cruiser for the Navy.' The vessel proposed in this paper was to be of 5000 tons displacement, of from 18 to 20 knots speed, was to carry coal for at least twenty-five days' full steaming, was to be armed with a suitable battery, —in short, she was to be an ideal ship, such as the world wanted, but could not get. After some discussion, and premature congratulation of the author, Kafer arose, and, going to the blackboard, chalked down on one side the 5000 tons displacement, then, on the other, his balance-sheet, thus:—Weight of machinery and boilers, of coal for twenty days' full steaming, of armament, and of ammunition,—total, 5500 tons, with no water in the boilers, no stores, and no men. 'The place of such a vessel,' said he, 'with weights far in excess of her displacement, would be, not that of a cruiser, but that of an anchor.' The author protested that he had attempted only to give ideal dimensions. Kafer's answer was that, since the paper would meet criticism abroad, it would better, first, undergo practical analysis at home."

Mr. Walter M. McFarland, acting vice-president of the Westinghouse Electric and Manufacturing Company, an engineer graduate of Annapolis, whose record is an honour to his *alma mater*, says, in writing of his student days:—

"Mr. Kafer was one of the early instructors in the engineering course at the Naval Academy, and every graduate of that course has felt the benefit of his work in shaping it. The great majority of the engineering graduates were actually his pupils, and so profited not only from the course as mapped out by him, but from the personal inspiration which came from association with a man of such marked ability. He had unusual adaptability to the work of instruction, and was able to present his subjects in such a way as not only to clear up doubtful points, but to arouse the enthusiasm of his students and stimulate them to their best work. Personally, he is one of the most agreeable of men, and one who has the faculty of attaching to him firmly the friendship of all whom he honours with his own."

Words such as have been quoted above could be multiplied, if there were need. The matter has been treated somewhat fully, since the course in marine engineering to which they refer was, when on the flood-tide of its usefulness, without an equal. Further, Mr. Kafer and the brilliant officers who, from time to time, were associated with him, builded better than they knew; for their work has left deep and lasting traces, not only on naval engineering, but, through the labours of the men whom they trained, upon the broad science of mechanical engineering, as practiced and taught in the United States to-day.*

In 1885 Mr. Kafer was asked to act as professor of mechanical engineering at Cornell University, but, because of ill health, declined the offer. After his

* Among the graduates of this course are:—Prof. Cathcart, of Columbia University, the author of this paper; Professors Hollis, of Harvard; Durand, of Cornell; Spangler, of the University of Pennsylvania; Cooley, of the University of Michigan, and Bull, of Webb's Academy, New York; Mr. William D. Weaver, one of the editors of the *Electrical World*; Messrs. Mattice, B. H. Warren, and McFarland, respectively chief engineer, vice-president, and acting vice-president of the Westinghouse Electric and Manufacturing Company; Lieutenant-Commander F. H. Eldridge, U. S. N., head of the Department of Steam Engineering and Naval Construction at the United States Naval Academy; Lieutenant-Commander F. H. Bailey, U. S. N., in charge of designs, Bureau of Steam Engineering, Navy Department, and many other most able engineer officers of the Navy. Admiral Bowles, chief constructor of the Navy, was originally a cadet engineer and a graduate of this course.—THE EDITOR.

retirement from active naval service he was in practice as a consulting engineer for a brief period in New York, and then became connected with the Morgan Iron Works, of that city. Of his career there, Mr. George E. Weed says:—

"In 1889, while president of the Morgan Iron Works, Mr. Kafer became associated with me, and so continued for ten years, filling successively the offices of superintendent, secretary and treasurer, and vice-president of the company. During these years I became familiar, not only with his qualifications as an engineer, but learned to value him as a companion and friend.

"Of the former I need not speak, since his record in the Navy and with those who knew him is established. I will note only that, with his engineering ability, I found coupled indefatigable energy. As an instance of this I may cite the transformation, in 1893, of the merchant steamer *El Cid* into the Brazilian cruiser *Nictheroy*, later the *Buffalo*, of our Navy, which work was done at the Morgan Iron Works under the supervision of Mr. Kafer in the short period of three weeks, during which time he was seldom absent for an hour, night or day, and was in demand continuously in all departments. His characteristics as a man, his strict integrity and genial good fellowship won him not only my regard, but the strong attachment of all connected with the works; and, when circumstances arose necessitating the discontinuance of our business relations, the separation was regretted by all."

Mr. Kafer is a member of the Military Order of the Loyal Legion and of George Washington Post (N. Y. C.) of the Grand Army of the Republic. He is, in length of service, the senior American member of the Institution of Naval Architects of Great Britain; a member of the American Society of Naval Engineers; a member of the council of the Society of Naval Architects and Marine Engineers; has been both manager and vice president of the American Society of Mechanical Engineers; is a member of the Army and Navy, and Players' clubs, of New York, and is now president of the Engineers' Club, of that city.

In the proceedings of the engineering societies with which he is connected Mr. Kafer has always taken a strong interest. In 1893, at the World's Engineering Congress, held in connection with the Chicago Exposition, he was of much aid to the division of Marine and Naval Engineering and Naval Architecture, of which his old chief, Admiral Melville, was chairman, both in technical discussions and in the entertainment of foreign guests, for which his wide acquaintance among engineers eminently fitted him. From the formation of the Society of Naval Architects and Marine Engineers he has been one of its most useful and energetic members. He has, also, given much time and service to the Engineers' Club. Mr. John Thomson, his distinguished predecessor in the presidency of the latter, says:—

"From the organisation of the Engineers' Club Mr. Kafer has been one of its most popular and active members, serving for years as vice-president and chairman of the house committee and, finally, being honoured by the presidency, which he now holds. In all of my more or less close contact with Mr. Kafer, as a member of the board of management of the American Society of Mechanical Engineers, through all our long association as trustees of the Engineers' Club and my subsequent three years' term as president of the club, our relations have been most cordial and satisfactory. He is a man with whom one can hold a decided difference of opinion and yet produce no loss of esteem,—a trait sufficiently rare to be noteworthy. His influence among men is distinctly to the good. Personally, I value his friendship highly; and, ex-officially, I can say, with full assurance of unanimous concurrence, 'We like him.'"

Tributes such as this and others which have been quoted herein are not lightly given. That they are accorded so freely to Mr. Kafer is due, not only to his long and successful service as an engineer, but to the fact that, with his strong and forceful traits, there are linked a winning gentleness and sim-

plicity of character. His straightforward words are never analysed to find a hidden motive, and, though stern if need be, they give no wanton wounds. Cultured, genial, and gallant, there is no finer representative than he of that old Naval Engineer Corps, which,—its mission ended,—has passed into history; which bridged the gap between the fighting sailor of the *Constitution's* day and the "fighting engineer" of our time; which served the Republic, with unwavering fidelity, throughout three wars; and which fought and won the battles of engineering on the sea.

With these closing words, the writer's thoughts turn backward to that old Academy beside the Severn, as it was a score, and more, of years ago, with its time-worn buildings, its velvet turf, its martial music, and, floating in the soft air, that bright flag, in whose service so many knightly lads of line and staff had left its halls to face wind and wave on many seas, to dare the tropic fever and the northern ice, to win, perhaps,

"Death's royal purple in the foeman's lines."

Throughout the recollections of those years as a cadet, of the hard study and unceasing drill, of youth's fond ambitions and its high ideals, there weaves, like a silver thread, the memory of John Kafer, rigid but kindly,—instructor, exemplar, and friend.

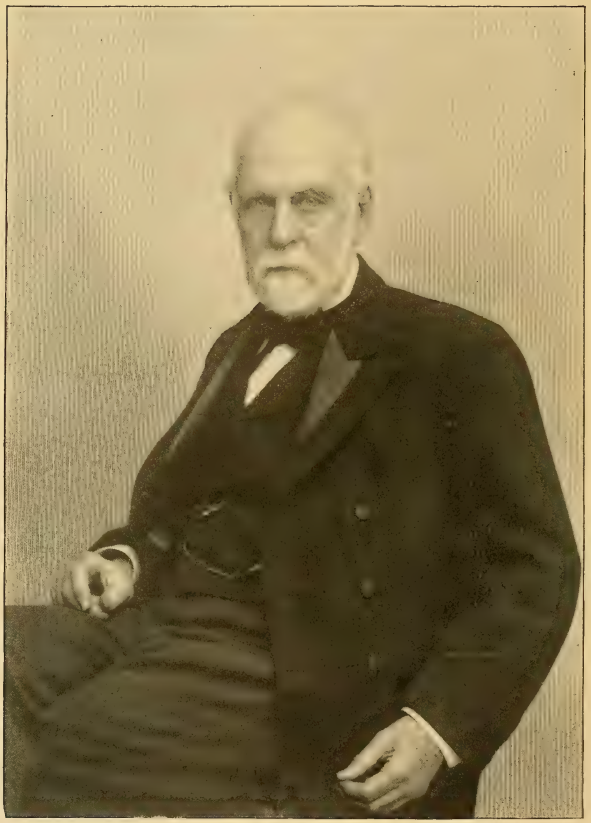


PHOTO BY ROCKWOOD, NEW YORK

Abram S. Hewitt

SEE PAGE 171

CASSIER'S MAGAZINE

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PATENT OFFICE

TOWN REFUSE DISPOSAL IN GREAT BRITAIN

ITS FUEL VALUE FOR STEAM RAISING

By W. Francis Goodrich, A. I. Mech. E.

NOTWITHSTANDING the extraordinary advances made within the past few years in the production of power from town refuse burned in destructors, there are still many engineers who doubt the value of such refuse as a fuel. The old maxim, "From nothing nothing is produced," is as true to-day as it was in the beginning, and as this is too often the text of the unbeliever, the writer would say at once that it is misapplied so far as refuse is concerned. Far from being nothing, or valueless, town refuse has a certain fuel value, varying of a necessity, and also fluctuating according to season and locality; but that it has a fuel value, is quite beyond all dispute.

Even if refuse possessed no potential energy beyond that necessary for its own cremation, the destructor would still be a necessity, if only from the sanitary standpoint. The waste of a community contains much that can be finally disposed of only in one way,—by fire. It should be quite unnecessary to labour on this point to any extent,—even the ancients recognised fire as the great purifier, the sanitary *sinê qua non*, and the Greeks, Romans, and Jews all thus disposed of their refuse. History records that in the valley of Gehenna the ancient Jews burned the refuse of Jerusalem; but, strange to say, the Jews have lapsed, and if a modern map of Jerusalem be examined, the site of the present "ash heaps" may be seen indicated just beyond the olive groves to the northwest of the city leaving by the Damascus gate. The latter-day Jews build these monuments of municipal wisdom which are such an ugly feature of our boasted civilisation. Although the accumulation of filth in this manner stands condemned by sanitarians and medical men all over the world, it is strangely persisted in by hundreds of thriving communities not only in Great Britain, but throughout the European Continent, the British colonies, and even in progressive America.

Perhaps one of the latest methods employed in America for disposing of refuse is that known as the "municipal hoggery," which system of disposing of garbage is in operation at Worcester, Mass. The overseers of the poor collect the city garbage and feed swine with it at the city farm, an average of 1800 swine being maintained by the garbage collected. The cost of collection for

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FIG. 1.—REFUSE TIPPED THREE MILES FROM OSBORNE HOUSE, ISLE OF WIGHT

FIG. 2.—ANOTHER VIEW SHOWING SWINE FEEDING ON THE REFUSE

the year 1900 was $17,000; receipts from the sale of pork, $11,300; net expense of the department, $5,700. This is truly a very businesslike statement, but there I pause; comment is needless. I am pleased to be able to say, after having interviewed the chief medical officers of health for New York, the leading cities of Australasia, and the Continent, that they all are quite unanimous as to the refuse destructor affording the only real, practical, and sanitary solution.

The more one looks into the matter, the more forcibly is this brought home. Even in some remote parts of the Indian Empire the natives mix their "kachera," or refuse, with their night soil and burn it, and, further, mark this, ye who doubt, these despised people use the heat produced therefrom for the burning of bricks, thus showing, if only in an elementary way, that they recognise the value of refuse as fuel, as well as the necessity for destruction by fire. Again, even away up in the Andes, where fuel, as we know it, is not available, and the vegetation is rare or stunted, the native values the animal excretal matter more than silver or gold; it is practically his only fuel; he destroys it by fire, and it yields a fuel value.

To come nearer home, extraordinary to relate, at a large number of towns all over Great Britain the refuse is either sold for a nominal sum, or given away to local brickmakers. In some instances

the authorities even deliver the refuse at a brick works and pay the fortunate brickmaker to accept it. Now, it is common knowledge that the cute brickmaker uses selected refuse as fuel at an immense saving, yet the same authorities, while being quite cognisant of the use to which the brickmaker puts the refuse, will scout the idea of a power destructor, or even the bare necessity for disposal by fire.

Such inconsistency needs no elaboration. If the brickmaker can burn the material in his very crude way, instead of coal, then how very much better must it be possible to deal with that same class of waste in a modern destructor built on scientific lines! And let this fact not be forgotten,—the brickmaker burns only selected refuse,—the significance to the sanitarian. During the last decade the growth of the population in London's outer ring has been phenomenal and alarming. To take a few examples,—

	Increase During the Past Ten Years	Present Population
Bexley	15,641	46,231
Croydon	35,820	194,519
Acton	17,668	48,913
Willesden	53,550	114,815
Tottenham	39,528	136,702
Edmonton	25,541	61,892
Enfield	11,202	42,738
Plaistow	32,887	90,917
Canning Town	14,908	69,658
East Ham	62,756	95,469
Walthamstow	51,561	108,931
Ilford	30,327	47,240

Let it first be understood that all the above-mentioned thickly populated districts in London's outer zone do not destroy their refuse. This may, at first sight, appear to be of little consequence.

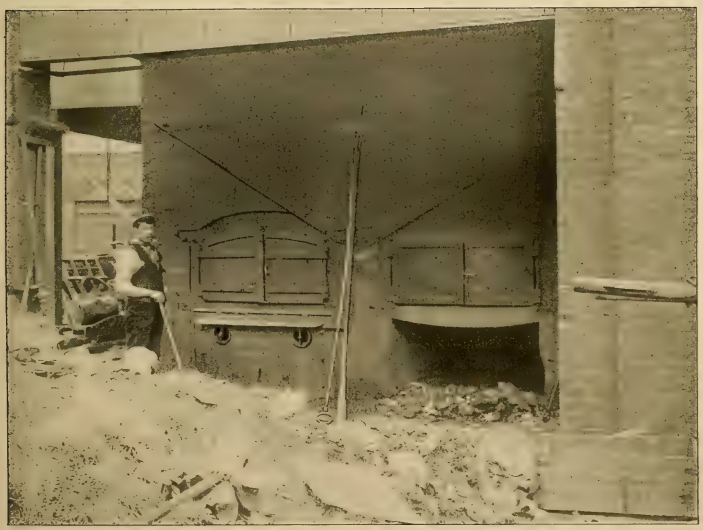


FIG. 3.—THE FIRST DESTRUCTOR CELLS ERECTED IN GREAT BRITAIN BY THE LATE ALFRED FRYER IN 1876

calorific portion. The larger proportion of filthy, objectionable, dangerous, and unsightly refuse is left to decompose, giving constant annoyance.

The recently published London census figures must appeal with remarkable

What thought does the average citizen give to the subject? It matters not what is done with the refuse,—sufficient if it disappears. But the interested, intelligent citizen, upon looking at these figures, must be struck with what is not

only a very unsatisfactory state of affairs, but also an utter failure to grasp proved elementary facts in sanitary science, to say nothing of the extraordinary economic phase.

We may assume that from fifteen to twenty cwts. of refuse are produced daily by each thousand of the population. Look at it from that point of view, and pause and wonder where the refuse goes to, bearing in mind that although a portion of the material will be harmless, yet a large percentage is filthy, putrescible, and dangerous. London's outer zone is not alone in this respect, but it is, perhaps, rather significant in being an insanitary belt around the great city. At Cardiff 85,387 tons of refuse are disposed of per year on two tips; at Croydon, 27,332 loads; Norwich, 24,000 loads; Portsmouth, 34,216 loads; and Swansea, 30,980 loads. This list might be extended, but a few representative towns should be sufficient.

Some would have us believe that a refuse tip is quite a salubrious spot, but the fact remains that land for the purpose cannot, as a rule, be obtained off the High street. The tip must be as far removed as possible; thus cartage is costly, and in many districts landowners are very loth to allow tipping at any price, far or near. When will those who are responsible for the public health realise that they are tipping not only filth and dangerous material, but power which could be utilised as an asset against the cost of destruction, and so for the general good of the community? The writer recently had an extraordinary case in hand,—a town within forty miles of London where eighty tons of refuse are produced per week. At the present time this is collected and tipped by a contractor at a cost to the ratepayers of £27 per week. Such a case will be scarcely credible,—6s., 9d. per ton are actually paid to get rid of the refuse. It has now been decided to erect a destructor on a central site and utilise the power for pumping the water supply for a population of 17,000. The benefits accruing will be, firstly, municipal control; secondly, sanitary disposal; thirdly, a coal bill of £500 per year saved; fourthly, low cartage cost; fifthly, sale of clinker products. It will thus be evident that, after making every allowance, in this case the adoption of sanitary means of disposal will actually reduce the rates, and thus at once benefit every householder. This case is not adduced as typical of hundreds, but has been introduced as typical of the general advantages of municipal control of collection and sanitary disposal.

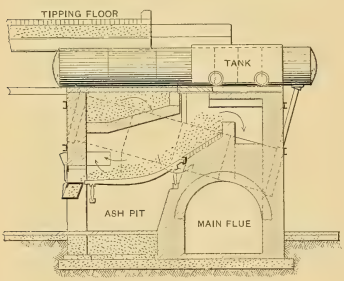


FIG. 4.—THE FRYER DESTRUCTOR

The writer fears that in the foregoing remarks he has told the sceptic much that he must have already known. If this all be common knowledge, then why has such ignorant and prejudiced opposition to be combated everywhere? This may be said, that those who will go into the matter with an open mind, and will investigate before they condemn, can be readily convinced; but unfortunately there are many of a different stamp. Their opposition, however, while tending to set the clock back and hinder the cause of progressive sanitation, has no effect in disproving the fact that refuse should be destroyed by fire, and that its recognised fuel value should be secured for power production for the general good of the community.

Perhaps no more glaring example of improper refuse disposal could be found than on the Isle of Wight, where the writer took the photographs from which the reproductions on page 100 were made. This blighted landscape was discovered about three miles from Osborne House, and only a few yards

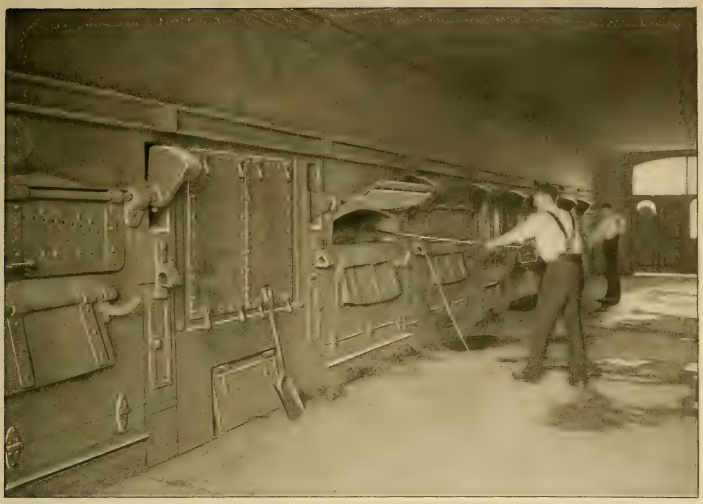


FIG. 5.—FRYER'S DESTRUCTOR AT CAMBRIDGE, ERECTED BY MESSRS. MANLOVE, ALLIOTT & CO., LTD., NOTTINGHAM. A BATTERY OF CELLS AND BOILERS

off a favourite road of the late Queen; in fact, Her Majesty passed this wretched place only a few days before her death. The upper illustration was reproduced from a photograph which the author obtained from the summit of a smaller heap of refuse than that shown, but as a closer examination of the large tip shown actually revealed some large, fat pigs browsing, he was inclined to bring his camera nearer, with the result shown in the lower illustration. No less than ten large pigs were on this enormous tip; only a few, however, can be seen, as several are resting peacefully in the filth, as is their habit. After this experience the author felt that the American municipal hoggery was not quite so unique, after all.

Only a few days after the author obtained these photographs the scavenging contractor was the defendant at the Isle of Wight County Court at Cowes in an action brought by the owners of an adjoining farm to secure damages for loss caused by the thousands of rats which infest the refuse tips. The plaintiff further asked for an injunction to prevent the continued deposit of refuse, and also an order of the court to remove the 5000 loads of refuse already accumulated.

A striking feature of the evidence was the gross ignorance shown, and the utter indifference to the sanitary aspect. The whole business was simply treated as a huge joke, although it came out in evidence that a dead cow, a dead pig, three dead sheep, and portions of a dead horse had been seen on the tip. According to the evidence given, similar refuse tips exist at East Cowes, Ventnor, and Shanklin, and rats live so luxuriously thereon that they do not leave the tip to feast on surrounding crops.

An injunction was granted, with an order that the refuse be removed within a certain period, and damages were assessed at £35. Of course, the refuse will simply be tipped on other land. The hearing of the case was accompanied by much laughter and fun, which is to be regretted. There was little reason enough for amusement, considering that only a few years ago a

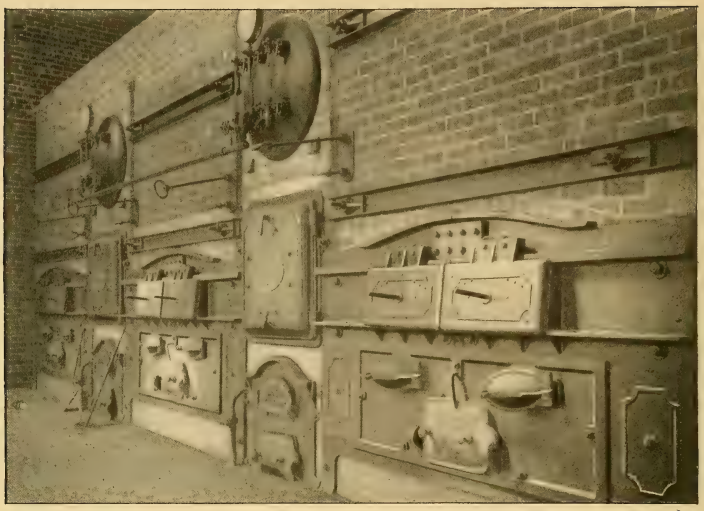


FIG. 6.—WARNER'S DESTRUCTOR AT WEST HARTLEPOOL. FRONT OF CELLS AND BOILERS

typhoid epidemic raged in the neighbourhood, the origin being attributed to the unsanitary conditions prevailing.

At Meopham, Kent, in the midst of beautiful scenery may be seen enormous quantities of refuse from the Newington district of London, hills of dusty, light refuse, and heap after heap of old tin cans, pails, saucepans, frying pans, and similar disused domestic utensils serve to remind one that it is still possible for one community to inflict its filth upon another, instead of finally disposing of it where it is produced. Travellers to the Isle of Wight via Portsmouth cannot fail to see and smell the immense accumulations of refuse on either side of the railway between Fratton and Portsmouth.

By the courtesy of Messrs. Manlove, Alliott & Co., Ltd., of Nottingham, the writer is able to reproduce, in Fig. 3, a photograph of the first two cells erected at the Water street depot of the Manchester Corporation about 1876. These furnaces were the first erected in Great Britain for destroying refuse, having been designed by the late Mr. Alfred Fryer, and worked by him for some time. The Meldrum forced draught system has lately been applied to one cell, and the burning capacity has thus been increased by about 50 per cent.

Great credit is due to the late Mr. Fryer, for in spite of much ignorant prejudice and opposition, he was the means of introducing the only real and practical solution of the refuse problem. It is quite true that the original design was weak; it is equally true that twenty-five years of experience have shown a very remarkable progress; but this in no sense detracts from the real value of Mr. Fryer's original invention and experiments. He undoubtedly was the pioneer, his task was a thankless one, and, at the time, brought him little satisfaction or recompense; but the outcome of his work has been phenomenal, and his name will always be honoured by those who are directly responsible for the public health.

The essence of Mr. Fryer's original patent was,—"charging or supplying the refuse to the cells at the back, and drawing out the clinker or residuum at the front," and here we have the main principle of a number of destructors to

this very day, with certain modifications and improvements, of course, but it will be seen that this is the basis of at least four destructors now on the market; only two or three have left the beaten track, and there is really only one on entirely different lines, namely, Meldrum's "Simplex," to which further reference will be made.

Suffice it to say that no better tribute to the inventive genius of the late Mr. Alfred Fryer could be possible than the fact that his principle is employed even after twenty-five years by some well-known makers of destructors. So much for the earlier efforts; but the main business of this article is to show what is being done at the present time.

Having insisted upon the vital necessity of final and sanitary disposal of refuse and its value as a fuel, the writer will endeavour to show later, by actual results obtained every day in many towns and cities, that as compared with coal for power production, the average

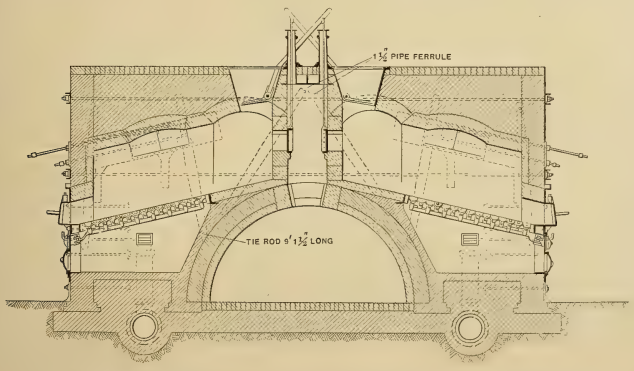


FIG. 7.—WARNER'S "PERFECTUS" DESTRUCTOR. SECTION THROUGH ONE PAIR OF CELLS. MADE BY MESSRS. GODDARD, MASSEY & WARNER, LTD., NOTTINGHAM

refuse has a definite value. In some towns its evaporative value is as high as one-fifth of that obtained by coal. This percentage of value differs with various types of destructors and various refuse from one fifth to one-fifteenth, but it can be said that the destructor may not fairly claim to be a power destructor when the evaporative value obtained from the refuse is less than one-tenth of that obtained from coal.

The only way in which the work of various destructors may be fairly compared is to select a number of installations within a comparatively small radius, taking care that the various towns chosen are of a similar character, and that, as far as possible, the coal used for domestic purposes costs about the same per ton in each town. If we are to make some comparison in this way we cannot do better than take the county of Lancashire, which is practically a coal-producing county, thickly studded with busy, populous manufacturing towns. It is well known to those at all intimate with the subject that the refuse of Lancashire towns is uniformly good, that is, it is high in calorific value, and, as a consequence, useful for the production of power.

If, therefore, it be assumed that the refuse is uniform in composition, then any difference in the results obtained in the production of power must be attributed to the difference in design and efficiency of the destructor. That is obvious, and need not be enlarged upon. As the writer wishes to avoid invidious comparisons, he has chosen a number of Lancashire towns, and has tabulated

TABLE I.—COMPARATIVE RESULTS FROM SIX DISTINCT TYPES OF DESTRUCTORS

	Town	Evaporation per Pound of Refuse	Average Steam Pressure	Temperature of Feed Water	Consumption of Refuse per Cell per 24 Hours	I.H.P. Produced per Ton of Refuse on a Basis of 20 lbs. of Steam per I.H.P.	Duration of Test	No. of Cells in Use	Rate of Combustion per sq. ft. of Grate per Hour	Boilers in Use	Test Conducted by
A	Oldham	.880	128 lbs.	212° Fahr.	1 Cell=7.96 tons	98 I.H.P.	24 hours	10	25 lbs.	2 Lancs 30'x8'	Lord Kelvin
A	Ashton-under-Lyne	.783	122 "	212 "	1 " =9.07 "	87 "	24 "	6	31 "	2 Multitubular	W. H. Vincent, Esq., Elec. Eng.
B	Bury	.532	------	53 "	1 " =9 "	59.584 "	4 "	6	33.6 "	3 "	—— Watson, Esq.
						T. C. Q. lbs.					
C	Rochdale	1.78	114	" 212	" 4 Grates=59 15 1 4	199 "	6½ "	4 Grates	54.9 "	1 Lanc 30'x8'	F. W. Brookman, Health Supt.
C	Darwen	1.55	103	" 212	" 4 " =32 2 1 6	173.6 "	48 "	4 "	56 "	" "	R. W. Smith Saville, Boro, Eng.
C_1	Nelson	1.516	118	" 212	" 4 " =61 0 0 0	169.792 "	9½ "	4 "	57 "	" "	J. A. Priestly, Health Supt.
C_2	Nelson	1.85	120	" 212	" 4 " =31 0 0 0	207.2 "	1 m. continuous	4 "	20 "	" "	" "
C_3	Nelson	1.05	122	" 212	" 4 " =73 4 0 0	218.4 "	3 hours	4 "	68.5 "	" "	" "
C	Blackburn ...	1.39	90.8	" 212	" 2 " =25 9 1 12	155.68 "	12 "	2 "	48 "	1 Babcock	W. Stubbs, A.M.I.C.E., Boro. Engr
D	Fleetwood ...	1.19	135	" 212	1 Cell=21 11 2 2	133.28 "	8 "	2 Cells	80.5 "	" "	Messrs. Meadhurst & Lloyd
D	St. Helens ...	1.54	127	" 212	1 " =27 12 0 8	172.48 "	7 hrs. 20 min.	2 "	104 "	" "	J. S. Highfield, Elec. Engineer
D	Warrington...	1.14	108	" 104	1 " =23 0 0 0	142.5 "	24 hours	2 "	88.48 "	" "	Geo. Darley
E	Blackburn ...	1.2097	122.3	" 212	1 " =11 3 0 12	145.264 "	7 hrs. 40 min.	4 "	34.66 "	2 Heenan Patent Water tube	W. Stubbs, A.M.I.C.E., Boro, Engr
										4 Babcock	
F	Liverpool	1.173	------	212 "	1 " =16 10 0 0	131.376 "	24 hours	8 "	62.16 "	" "	----------

The letters A to F indicate the different types of destructors working in twelve well-known Lancashire towns.

the names only, without mentioning the type of destructor in use. A careful selection of all the results so far available gives the analysis in Table I.

It will be evident from this table that there is a wide difference in the results. To make it quite clear to the reader that the difference is due to the type of destructor in use, and not by reason of any serious difference between the qualities of the refuse, the writer has indicated each distinct type of destructor by a letter. This will serve to show that where one particular type of destructor is in use in two, three, or even four different towns, the results obtained are remarkably uniform. This indisputable fact will dispose of some prevalent theories, but we must have logical facts in order to arrive at definite conclusions.

Within the limits of this article it is possible to give only a brief description of the various British destructors, and in doing so the writer will point out the leading and distinctive features of each, also briefly describing a recent installation, with the latest facts and figures available in each case.

THE FRYER DESTRUCTOR, WITH BOULNOIS, WOOD & BRODIE'S COMBINATION

A very clear general idea of the arrangement of this combination may be obtained from Fig. 4. This method of charging is unique, and it is claimed that a considerable saving in labour is effected, with a consequent reduction in the cost per ton of material destroyed.

The charging appartus consists of tanks divided into several compartments, each of which contains sufficient refuse for one charge. These tanks travel on rails under the tipping floor, the carts tipping the refuse through openings above into them. They are moved along the rails as required, so that the bottom of any compartment may be brought directly over the arch of the cell; the sliding top is then removed and the hinged bottom of the compartment is opened automatically downwards, releasing a charge of refuse on to the drying hearth. Then the

human element comes in, the refuse having to be raked forward and levelled, as would be the case with an ordinary top or back feed.

The tanks are moved as required by an arrangement of winches on the tipping floor. The fire-bars are of somewhat curious form, taking a rather sharp curve, and are of the movable or rocking type, alternate bars being moved by toggle gearing. Artificial draught is usually provided by fans.

A water-tube boiler is set between a pair of cells, the gases thus entering from right and left. Further, the boiler is provided with an ordinary grate for coal firing in the usual manner, so that it can be worked with refuse and coal together, or with either separately, as required. Besides, the boiler furnace may be used as a cremator.

As a large and representative installation under these patents, the plant may be mentioned which was erected for the Liverpool Corporation, generally known as the St. Domingo destructor. Particulars of a twenty-four-hour test with this are given in Table II. on page 108.

The Fryer destructor, illustrated in Fig. 5, is the installation erected by Messrs. Manlove, Alliott & Co., Ltd., about four years ago at the sewage works at Cambridge. The plant consists of six cells, with three Babcock & Wilcox boilers, a boiler being "sandwiched" between two cells. Boulnois & Brodie's charging tank arrangement is also employed. Only four cells and two boilers are in use at one time, the rate of consumption being about seven and one-half tons per cell per twenty four hours.

The available power is used for pumping the sewage of Cambridge and Chesterton by means of two 80-H. P. tandem, compound condensing pumping engines. Steam is used also for driving a 4-foot 6 inch diameter fan direct-coupled to a high speed engine.

WARNER'S DESTRUCTOR

The makers of this destructor, shown in Fig. 7, have had considerable experience, and claim to have erected nearly 600 cells; but like the makers of the destructor last dealt with, the majority of their installations have been of the old, low temperature type. In construction the Warner cell is very similar to the Fryer, both as arranged in single row, or back to back. The charging arrangement is of a special type peculiar

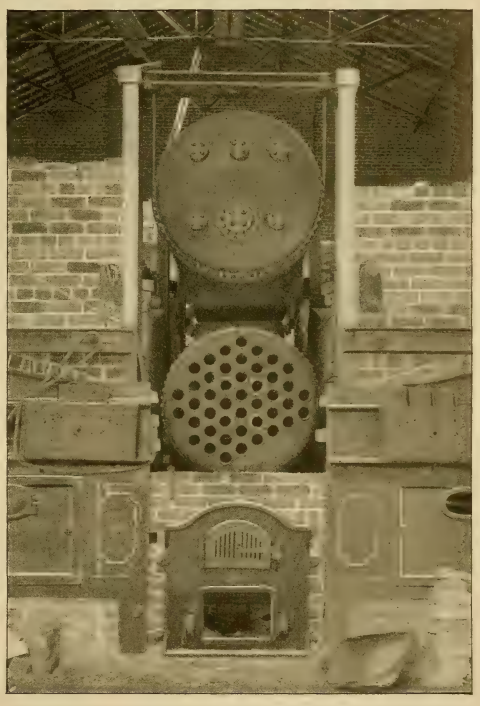


FIG. 8.—WARNER'S DESTRUCTOR AT WEST HARTLEPOOL, SHOWING POSITION OF BOILER WITH SEPARATE FIRING DOOR

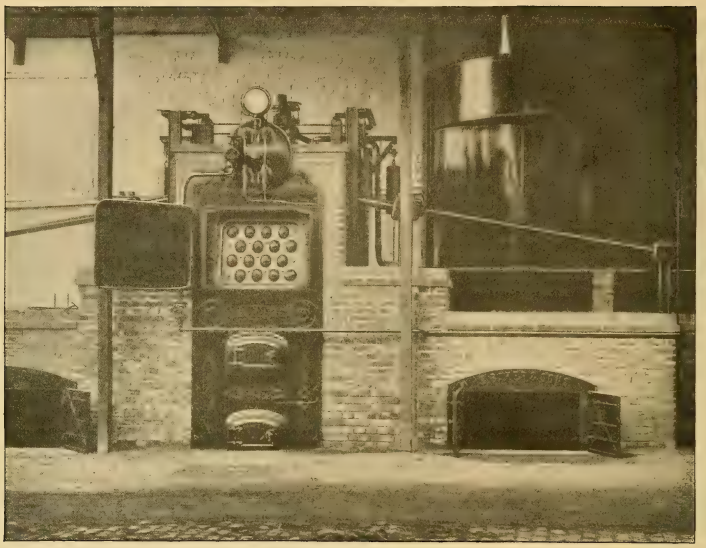


FIG. 9.—BAKER'S DESTRUCTOR AND HORNSBY BOILER FOR THE CLERKENWELL VESTRY. INSTALLED BY MESSRS. JOSEPH BAKER & SONS, LONDON

to this destructor. A hopper is set immediately at the back of the drying hearth, with a movable plate at the top to prevent the escape of fumes, while at its base there is a hinged door, which is opened, as required, by a lever on the tipping floor. The contents of the hopper, being released, fall on to the drying hearth, from which point the refuse has to be raked forward and levelled.

It will be noticed that the grate surface is inclined. In the past, rocking bars were employed, but it is usual now to fix stationary grates. A reverberatory fire-brick arch is arranged over the drying hearth and grate, with outlet flues at the side, as will be seen from the illustration. Flap dampers, operated by levers, are used, making it possible to isolate any one cell or cells for repairs.

These dampers are also used for throttling the draught and preventing a great inrush of cold air during clinkering. It will be obvious to all that dampers are useful, but in high-temperature destructors they are a constant source of

TABLE II.—TEST AT ST. DOMINGO DESTRUCTOR, LIVERPOOL, ERECTED BY MESSRS. MANLOVE, ALLIOTT & CO., LD., NOTTINGHAM.

	Tons.	Cwts.	Qrs.	Lbs.
Total refuse burned in 8 cells in 24 hours	123	16	0	0
NOTE:—23 tons were burned in 6 hours between 12 midnight and 6 A.M. The boilers were not in work during the period, and the gases were passed through the by-pass flue direct to the chimney	23	0	0	0
Refuse burned in 8 cells in 18 hours	100	16	0	0
Refuse burned in 8 cells per hour	5	11	0	0
Refuse burned per cell per hour		13	3	24
Refuse burned per square foot of grate surface per hour			62	16 lbs.

	Lbs.
Total quantity of water evaporated per hour	14,581
Total quantity of water evaporated per cell per hour	1,823
Total quantity of water evaporated per lb. of refuse burned	1,173
Indicated horse power produced per ton of refuse burned, on a basis of 20 lbs. of steam per I.H.P. per hour	131.376 I.H.P.

trouble, and in the best modern designs they are not employed unless it is absolutely necessary. It has been found with some recent high-temperature destructors that the dampers give considerable trouble, and instances might be cited where even elaborate water-cooled dampers have become useless in a very short time; in fact, if modern experience teaches anything here, it is that simplicity is an essential, and that the use of dampers should be restricted as far as possible. Fan draught is now installed with most cells of this type. One of the most recent installations, of Messrs. Goddard, Massey & Warner, Ltd., of Nottingham, is that at West Hartlepool, illustrated in Figs. 6 and 8. The general arrangement is identical with that shown in the sectional view, Fig. 7.

BAKER'S DESTRUCTOR

This is a comparatively new destructor, of which there is only one example in Great Britain, that erected for the Clerkenwell Vestry at their Lambeth wharf. The patentees have, however, considerably modified the design since this installation was made, principally in the provision of large storage hopper capacity on similar lines to Messrs. Horsfall's experiment at the Strand destructor. Another new feature is a tipping dead-plate with a shoot to deliver the clinker into a conveyor, where it is cooled by a water spray in transit. How far these innovations are of service yet remains to be proved so far as this particular destructor is concerned.

Owing to the nature and formation of clinker, it has been found that automatic devices hinder instead of help, and waste valuable time. The writer says valuable time advisedly, because in the case of a power destructor clinkering must be done smartly, and, so far as the writer is aware, no process has yet been evolved which can compete with a live man.

The general design of Messrs. Baker's destructor with the latest improvements is shown in Fig. 10. At Lambeth, the two cells, each with 42 square feet of grate surface, are placed below the ground level. The refuse, being tipped in front

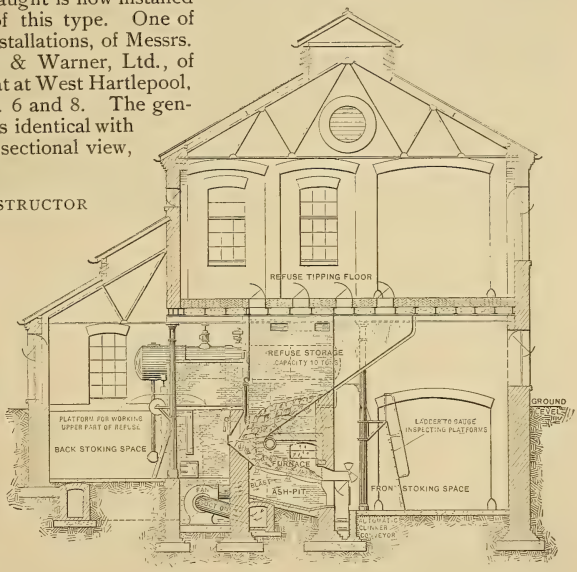


FIG. 10.—THE LATEST FORM OF DESTRUCTOR MADE BY MESSRS. BAKER & SONS, LONDON

of the firing doors, is fed by hand on to an inclined drying hearth beneath, the grate proper being situated below, also at an angle. At the back of the drying hearth and at that point where the refuse leaves the drying hearth for the ordinary grate a door is placed, and from there the refuse can be assisted in its travel and is manipulated and levelled. At the opposite end of this grate, and at a lower level again, is the clinkering door.

Above the drying hearth there is

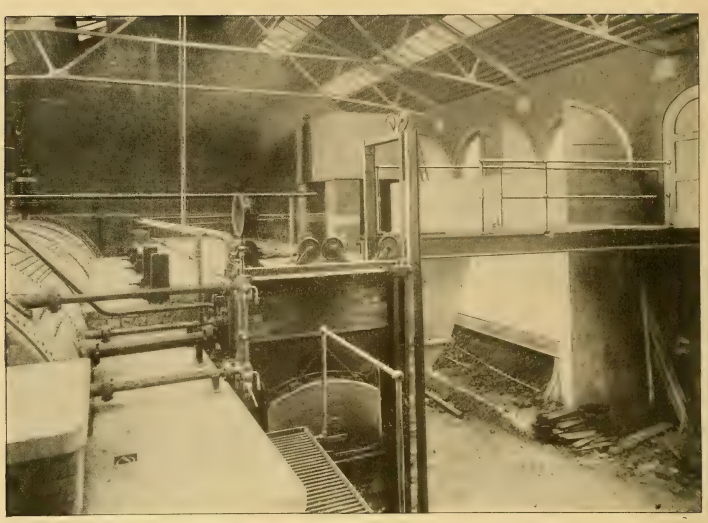


FIG. 11.—MELDRUM'S DESTRUCTOR AT NELSON. END VIEW OF CELL WITH OFFAL CHARGING ARRANGEMENT AND CONTAINING HOPPER

placed an exhaust flue so arranged that the gases there distilled must pass in that direction and thence through the fire beneath; this is certainly a good arrangement, but how it would work out, in the latter design with large storage capacity, yet remains to be seen.

In the Lambeth installation a water-tube boiler is placed between the two cells and a large dust catcher is provided. The refuse dealt with at these works is of a very light character, being practically free from breeze, cinder, and ash. Offal, carcasses, and the various heavy ingredients which go to make up the average refuse, are not burned there. The destructor certainly has some good features and is novel in design, but it can be judged only according to the prevailing conditions. To compare it with the other types is scarcely possible. To do this fairly would necessitate the destruction of average refuse, while at present the authorities find it to be more profitable to sort the refuse, the breeze and cinder being disposed of to brick-makers; the incombustible material is barged away.

MELDRUM'S DESTRUCTOR

Meldrum's Simplex or regenerative destructor was introduced about eight years ago, the first installation being made at Rochdale. Since then it has been extensively adopted, and the results obtained have been uniformly excellent, more particularly in the maintenance of a high temperature and in the quantity of steam produced. A few years ago it was considered quite impossible to produce high-pressure steam from boilers fired with destructor gases. Actually, at so recent a date as September, 1899, at Darwen, steam was produced at a pressure of 200 pounds to the square inch for the first time, the steam there being used for electric lighting and traction.

So far as the writer is aware, Darwen is still the only place in Great Britain where steam is produced at 200 pounds pressure from refuse destructor gases alone, although it is to be shortly followed by Lancaster, where a similar plant is almost ready. There the power will be used for electric traction.

In briefly describing Meldrum's de-

structor, it may be observed at the outset that it is entirely different in design from those types already dealt with, and does not appear to follow the lines of previous destructors. It is important that any departure from the beaten track should be emphasised, because so many people with only a hastily acquired and superficial knowledge of the subject possess the notion that destructors are as similar as peas.

In the present instance instead of two, three or four small cells, each with 25 or 30 square feet of grate area, as the case may be, one large cell or unit is provided, with a long, continuous grate, but divided ashpits. It is, therefore, possible to work the whole of the grate, or any particular section or sections, as may be required at any time (see Fig. 12). The ashpits are isolated, quite distinct and independent of one another, forced draught by means of Meldrum's steam jet blowers being supplied to each ashpit, under separate control.

Above the grate is one continuous chamber, instead of division walls and isolated cells; consequently any section of the grate which is temporarily idle for clinkering or charging is always in a zone of active incandescent fire, because the other sections of the grate are in full work. There can be no doubt that this system of working, together with the regenerator which we shall consider directly, is largely responsible for the easy maintenance of a high tem-

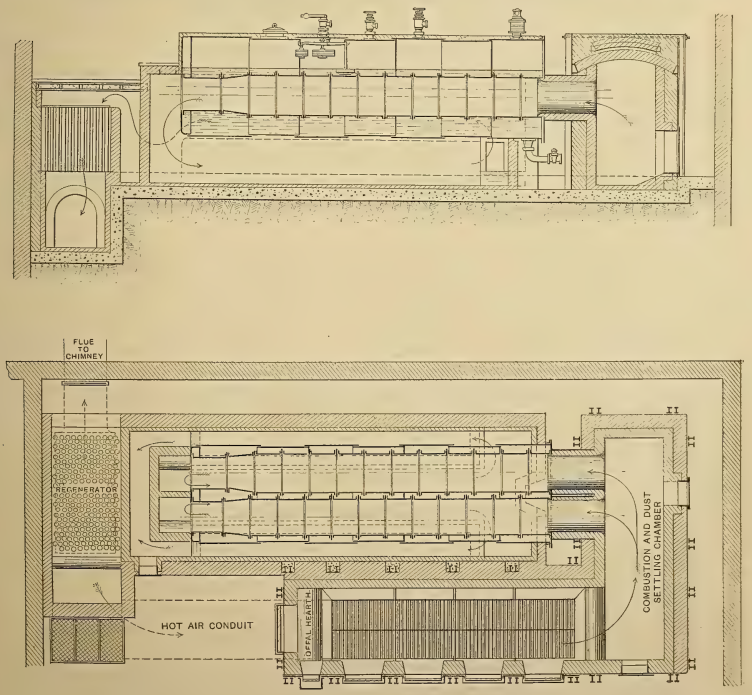


FIG. 12.—DIAGRAMS OF A MELDRUM DESTRUCTOR SHOWING PATH OF COMBUSTION GASES THROUGH BOILER AND REGENERATOR. ERECTED BY MESSRS. MELDRUM BROTHERS, LTD., MANCHESTER

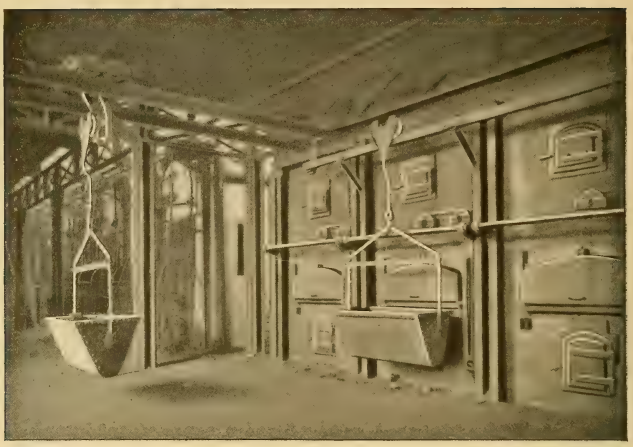


FIG. 13.—HORSFALL'S DESTRUCTOR PLANT AT FULHAM

perature and the very slight fluctuation in steam pressure.

In the ordinary arrangement of this form of grate the gases have a sideway motion, the whole volume moving in one direction and passing over the bridge and into the combustion chamber, then through and around the boiler. Leaving the boiler, the gases are carried through an uptake and then dip down through what is termed the air heater or continuous regenerator, which consists of a number of specially constructed cast-iron pipes, through which the waste gases pass, cool air circulating around the outside of the pipes.

The heated air is drawn from the regenerator through a conduit and delivered to the blowers under the grate of the cell through uptakes at a temperature of about 300° Fahr.

The drying hearth is done away with, the continuous grate and hot air supply rendering it quite unnecessary even with very wet material. Another innovation is the system of firing which is known as the front hand feed, and is peculiar to this type of destructor. The containing hoppers in which the refuse is tipped are placed parallel with the cell and the refuse is all shoveled in by hand direct from the hopper; thus there is one operation only, the refuse being fed in as wanted, and needs no further attention until it is removed in the form of hard clinker; it is not raked or leveled, both of which operations have to take place in the case of a top or back feed.

Particulars are given in Tables III. and IV. of two remarkable tests with the plant at Nelson. Test No. 1 was of one month's continuous duration. So far as the writer is aware, this is the first test ever made over such a long period, and it is especially valuable as conclusively proving, once and for all, the practical value of the destructor as a power producer. Mr. J. A. Priestley, the health superintendent of Nelson, has rendered a good service to sanitary authorities by placing on record the very complete data of a thorough test under normal working conditions over such an extended period.

Table IV. is also of value as showing how a destructor can be forced over short periods to meet exceptional demands for steam. It will be noticed that the general efficiency is not sacrificed, and that the plant is exceedingly elastic.

THE HORSFALL DESTRUCTOR

It may be fairly claimed that this was the first high-temperature destructor, although it was very soon followed by Meldrum's first destructor at Rochdale. The Horsfall destructor has been extensively adopted, and a brief description will here suffice. Generally speaking, it consists of a furnace, or furnaces, each of which is a separate cell with about 30 square feet of grate surface, in addition to an inclined drying hearth, which, as will be seen from Fig. 12, is situated over the main flue, the grate proper being arranged over the blast flue. One special feature is the outlet flue, situated at the front in such a position that all fumes distilled from the refuse on the drying hearth must pass over the burning refuse and commingle with the gases therefrom before escaping through the outlet flue. It may thus be fairly assumed that if good fires are kept in the cells and a high temperature is maintained in the main flue, nuisance should not be possible; but a high temperature beyond the cells is an essential, not only to avoid the possibility of nuisance, but to ensure good steaming results. These remarks apply not only to this particular destructor alone, but to every type where each cell is distinct in itself.

Other special features of the Horsfall destructor are side air boxes, which give an air circulation and tend to prevent clinker adherings to the side walls of the cells, and a steamblast apparatus, which is of a special type known as the flat jet.

In order to justify its employment, steam blast must be so designed as to be able to compete with fan blast in consumption of steam, or what is the same, useful energy expended. It is contended that this is impossible, but experience proves otherwise; for instance, at Shoreditch, where electrically-driven fans are in use, it is said that 14 per cent. of the total steam produced is thus absorbed, while at Rochdale, Hereford, and Darwen from 12 to 14 per cent. only is used for the steam blast, and it should be borne in mind that the rate of combustion per square foot of grate area at the three last named installations is higher than at Shoreditch. This is mentioned merely in passing, because artificial draught in one form or another is a necessity, and it is just as well that a clear understanding should exist as to the comparative working expenditure in energy or useful power. That this is a matter of the highest importance will be obvious to all. If we recognise the fuel value of refuse, it is surely folly to thus waste power which might be profitably employed in another direction.

The system of charging the cells remains practically unaltered, as will be seen from Fig. 14. A few months since

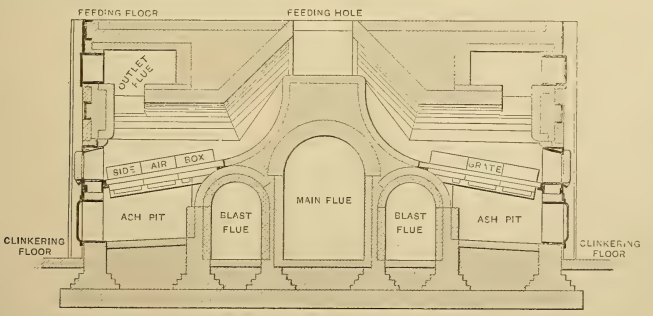


FIG. 14.—HORSFALL DESTRUCTOR CELLS, ARRANGED BACK TO BACK. BUILT BY THE HORSFALL DESTRUCTOR COMPANY, LTD., LEEDS

TABLE III.—OBSERVATIONS MADE DURING FOUR WEEKS WORKING OF MELDRUM'S REGENERATIVE REFUSE DESTRUCTOR AT NELSON. FROM 10.15 A.M., FEBRUARY 19TH, TO 10.30 A.M. MARCH 16TH, 1901.

Number of cells or grates	4	Grate area	100 sq. ft.
Lancashire boiler	30 ft. x 8 ft.	Heating surface	986 sq. ft.

Refuse consumed	Tons.	Cwts.
Ordinary ashpit refuse	571	12¾
Light refuse	29	11¾
Vegetable refuse	9	0¾
Fish and offal	16	18
Total	627	2¾
Less pots, tins, &c. not burned	13	3¾
Total weight of refuse consumed	613	19½

Weight burned per day of 24 hours	31 tons.
Weight burned per square foot of grate per hour	29 lbs.
Water evaporated per hour from and at 212 deg. Fahr., average	538 gallons.
Water evaporated per pound of refuse from and at 212 deg. Fahr.	1.85 lbs.
Water evaporated per square foot of heating surface per hour, from and at 212 deg. Fahr.	5½ lbs.
Average temperature of combustion chamber (51 readings)	1959 deg. Fahr.
Average temperature of downtake	1070 deg. Fahr.
Average temperature of side flues leaving boiler	654 deg. Fahr.
Average temperature in main flue (after regenerators)	410 deg. Fahr.
Average temperature of heated air	243 deg. Fahr.
Average air pressure in ashpits	1½ in. of water
Average steam pressure	120 lbs.
Average temperature of feed water	59.8 deg. Fahr.
Percentage of clinker	30.2 per cent.
Percentage of fine ashes from ashpits	3.4 per cent.
Percentage of flue dust (the majority of which settled in the combustion chamber)	5.05 per cent.
	8.65 per cent.

NOTE.—The above observations were made while the plant was working under ordinary normal conditions, including banked fired at week ends.

TABLE IV.—TEST OF MELDRUM PATENT REGENERATIVE REFUSE DESTRUCTOR AT NELSON, APRIL 25TH, 1901.

	Tons.	Cwts.	Qrs.	
Duration of test				8 hours.
Refuse delivered	25	2	1	
Less pots and tins		12	3	
Total refuse burned	24	9	2	54,824 lbs.
Refuse burned per hour				3 tons, 1 cwt. 6,853 lbs.
Refuse burned per square foot of grate per hour				68.5 lbs.
Total water evaporated (actual)				91,600 lbs
Water evaporated per hour average (actual)				=1,145 gallons.
Water evaporated per hour from and at 212 deg. Fahr. average				=1,337 gallons.
Water evaporated per hour (average) from and at 212 deg. Fahr. per square foot of heating surface				13.5 lbs.
Water evaporated per pound of refuse (actual)				1.67 lbs.
Water evaporated per pound of refuse from and at 212 deg. Fahr.				1.95 lbs.
Average steam pressure				122 lbs.
Average feed-water temperature				83 deg. Fahr.
Percentage of Clinker				29 per cent.
Percentage of fine ashes from ashpits				1.8 per cent.
Average temperature of combustion chamber				2,227 deg. Fahr.
Average temperature in downtake				1,306 deg. Fahr.
Average temperature in side flues, leaving boiler				922 deg. Fahr.
Average temperature in main flue after regenerator				394 deg. Fahr.
Average drop in temperature due to regenerator				256 deg. Fahr.
Average temperature of heated air from regenerator				304 deg. Fahr.
Average temperature of air entering regenerator				82 deg. Fahr.
Average percentage of carbonic acid				14.4 per cent.

a new arrangement was tried in connection with the destructor erected for the Strand Board of Works, the idea being for the large motor vans to tip the refuse direct into a large containing hopper, the base being the drying hearths of two cells arranged back to back, the refuse then being raked and levelled on to the grate proper in the usual way. Much was expected from this arrangement, more particularly in reducing the cost per ton by minimising the handling of the material, but it is understood that it has not come out as anticipated; in fact, the storage of so much refuse has proved to be impracticable.

A recent example of a Horsfall destructor in London is that at Fulham. Fig. 15 clearly shows the general arrangement. The installation consists of twelve cells arranged back to back in two groups of six each on either side of a battery of six Babcock & Wilcox boilers. Space is left for four additional cells. Each cell has a capacity of ten tons per twenty-four hours, equal to a

rate of combustion of thirty-one pounds per square foot of grate surface per hour.

Over the boiler firing and refuse clinkering floor, and extending from end to end of the building, is the tipping floor, to which the carts are brought for the purpose of discharging their loads of refuse on the tops of the groups of cells, whence the refuse is fed into the furnaces. The tipping floor is amply large to allow for the storage of a considerable quantity of refuse. It is reached by means of an inclined roadway with a gradient of about 1 in 14, all the refuse having to pass over a weigh bridge at the foot.

The cells have a grate area of 30 square feet each. The boilers were supplied by Messrs. Babcock & Wilcox, and each have 1284 square feet of heating surface. Not only are the boilers fired with the destructor gases, but each is equipped with Vicar's mechanical stoker, and also forced draught. Two Green economisers are provided, being placed between the boilers and the dust catcher which is of the usual centrifugal type. It is estimated that the refuse will show a calorific value of one-twentieth that of good steam coal.

It may be fairly assumed that at Fulham refuse disposal was the primary consideration, and that the possible power production, while being carefully borne in mind, was not taken at too serious a computation. A hasty calculation has led the writer to this conclusion, because it is very doubtful if refuse can be destroyed in London for less than 1s. per ton; thus twenty tons of refuse, or the estimated equivalent of one ton of steam coal, would cost 20s. for the labour involved in burning. Now the labour cost for burning one ton of best steam coal in London does not exceed

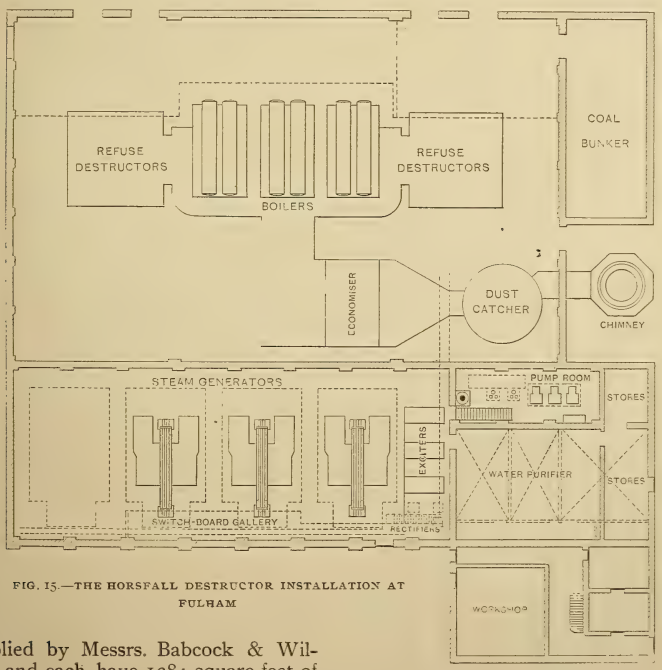


FIG. 15.—THE HORSFALL DESTRUCTOR INSTALLATION AT FULHAM

4s., or, say, one-fifth that of refuse employed as a fuel. Thus, looking at both from the fuel point of view, and estimating the cost of best steam coal at 25s. per ton delivered, we arrive at the following result:—

20 tons of refuse=1 ton of steam coal at 25 shillings per ton delivered.	
Cost of labor in burning 20 tons of refuse, equivalent to one ton of coal	20s.
Cost of labor in burning coal	4s. per ton.
Estimated value of refuse per ton as fuel at the works	1s. 3d. per ton.

From this must be deducted the cost of collection and delivery, and also the cost of labour involved in burning. It will thus be evident that if the burning of 40,000 tons of refuse per annum does save the cost of 2000 tons of Welsh coal, yet a net saving is quite impossible, for obvious reasons.

HEENAN'S TWIN-CELL DESTRUCTOR

This is a comparatively new type of destructor, having come into prominence only within the past year. Briefly described, it consists of a pair of cells, each having 30 square feet of grate area, or thereabouts. The two cells are partially divided only by a central division wall, which is, however, clear of the crown arch. There are two charging doors on the ground level, one to each cell, a damper being placed in the combustion chamber in such a position as to control the travel of the gases. The cells are so worked that one is always in an active state when the other is ready for clinkering and charging. (See Fig. 17.)

FIG. 16.—TWIN-CELL DESTRUCTORS AT BLACKBURN, INSTALLED BY MESSRS. HEENAN & FROUDE, MANCHESTER. A VIEW OF THE CLINKERING FLOOR

The manipulation of the cells with the damper is so arranged that one cell is at all times acting as a cremator for the other cell, the travel of the gases being so controlled that the gases dis-

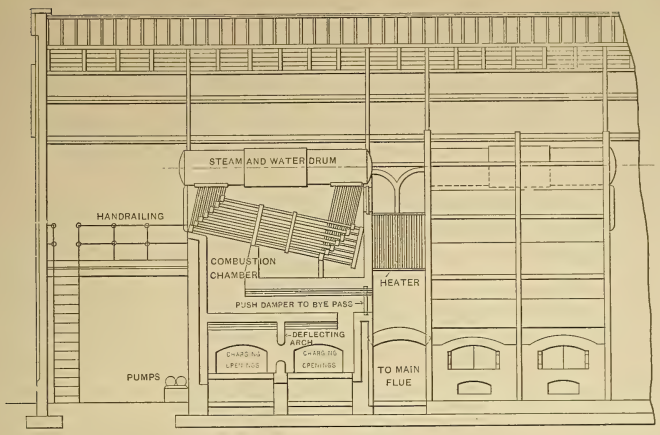


FIG. 17.—ELEVATION AND SECTION OF THE DESTRUCTOR AT BLACKBURN

tilling from a fresh charge can escape only through the cell which is in active work. The principle is good, but is not peculiar to this one type of destructor, although in this case the commingling of the gases is secured earlier than is the case with those destructors which have distinct cells and deliver their gaseous products into one common main flue, and, therefore, advantageous when each twin-cell is worked in conjunction with one boiler. To this extent the twin-cell has an advantage over all systems of isolated or distinct cells, whether in single row or back-to-back arrangement, the principle being a sound one.

Although the main features of the original twin-cell are maintained, yet a number of modifications have been made, the chief one being the omission of the regulating damper. A plant so modified is now in successful operation at Rawtenstall, Lancashire.

Perhaps the most important addition to the original form of cell is that of Howden's system of forced draught with hot air for combustion. This is obtained by passing the air for the draught through an air heater made of wrought-iron boiler tubes, placed in the downake from the boiler. The air is passed into the cells, both above and below the grates, at a temperature exceeding 300° Fahr. This system of draught has been very extensively adopted in marine work where the highest economy is essential, but has hitherto been employed on land only to a limited extent.

An important feature of the system in conjunction with destructor furnaces is that, without the aid of dampers, cold air is prevented from entering the cells when the doors are open for charging or clinkering. Fans are exclusively used with this type for the production of draught, and the makers claim to use but one-third the steam required for a live steam jet. The exhaust steam is also utilised.

Another feature of this destructor is a water-tube boiler which is used in connection with it. It is, however, somewhat premature to express any opinion as to the performance of this boiler. Generally speaking, water-tube boilers possess some advantages over shell boilers for destructor work, but the advantages may be summarised as greater heating surface in a given space, economy of space, and greater absorption of radiant heat; against these advantages the Lancashire boiler has large water and steam space and great simplicity, all of which

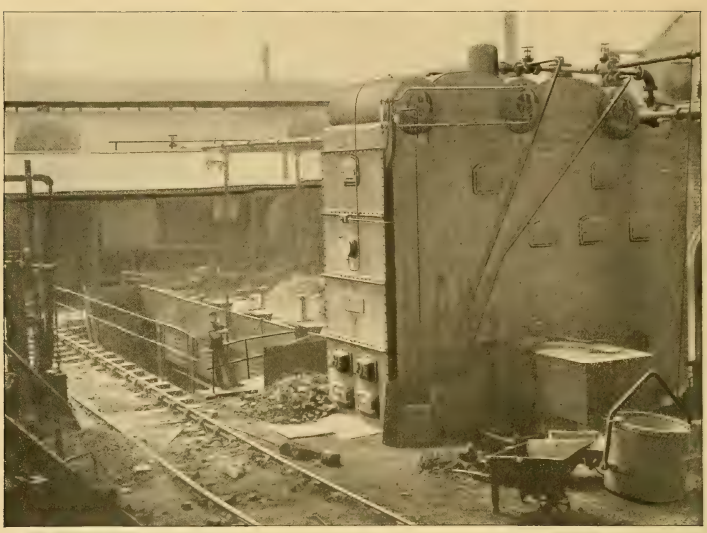


FIG. 18.—MASON'S GASIFIER AT MESSRS. BOLCKOW, VAUGHAN & CO.'S STEEL WORKS AT MIDDLESBOROUGH. SET WITH A 600 H. P. STIRLING BOILER

are of the highest importance in connection with power destructors.

The water-tube boiler is a rapid steam raiser, but also a rapid steam loser, while the Lancashire boiler, by reason of large storage capacity of steam and water, has a goodly reserve of power, which is of immense value in connection with the power destructor, being, as it is, a useful set-off against possible fluctuations in the quality or condition of the refuse and also laxity on the part of the men, as will happen occasionally.

Thus far Messrs. Heenan have not completed installations with other than their water-tube boiler, but they hold several orders for plants where Lancashire boilers are to be used, and it will be interesting to see the results obtained with this altered condition. The only complete installation so far erected under their first patents is that at Blackburn. Particulars of a recent test with this plant are given in Table V.

The high temperature of the escaping gases will be noted. The makers now claim to be able to reduce this considerably, and thus increase the efficiency.

MASON'S REFUSE GASIFIER

This apparatus has come well to the fore in recent years, but has been adopted in a few towns only for the destruction of refuse. Strictly speaking, it is not a destructor, but a gasifier, and is, perhaps, more successful when dealing with one particular kind of waste fuel, such as furnace breeze, rather than the extraordinary mixture of which the average refuse is composed.

The general design will be clearly seen from Fig. 19. The cell, which may be rectangular or circular in cross section, is built up of cast-iron plates, lined with fire-brick, the top being closed in and provided with a hopper and barrow opening for charging purposes. At the bottom the cell is open and supported on two sides across a water-trough which covers the whole area of the base, the level in the trough being maintained at such a height as to effectually seal the interior of the cell

from the outer atmosphere. Running transversely across the water-trough is a cast-iron chamber, fitted at the top with two inclined grates above the water level, which form a ridge running from side to side of the cell.

The supply of air for combustion is delivered by a steam jet blower into this cast-iron box, and thence through the body of refuse or fuel, as the case may be. The rate of combustion and temperature are kept low,—just sufficient to distil off the carbonaceous or organic matter, the gases then being passed into a separate chamber, where they receive a secondary supply of air to secure their ignition and complete combustion at a temperature of about 1800° Fahr. The combustion chamber is surrounded with an annular jacket, from which the secondary air is drawn after being heated.

It will at once be seen that this gasifier is a radical departure from the general design of refuse destructors, and

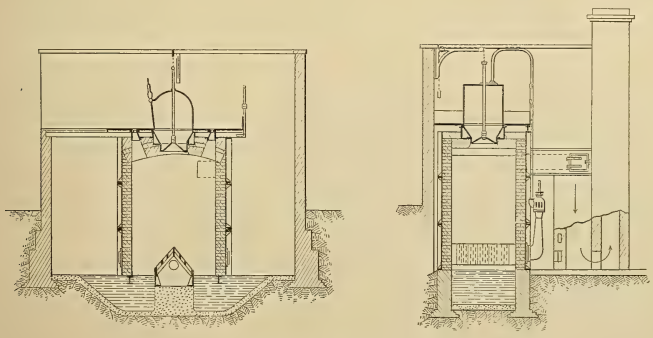


FIG. 19.—MASON'S REFUSE GASIFIER. A ONE-CELL PLANT

that it possesses some novel features; but so far as the information available shows, although successful within its limited sphere, the process cannot very well compete with modern high-temperature power destructors, for very obvious reasons.

Fig. 18 represents one of Messrs. Mason's plants at the steel works of Messrs. Bolckow, Vaughan & Co., at Middlesborough, installed to utilise breeze, which was formerly a waste product, the resultant heat being absorbed by a Stirling boiler of 600 H. P.

THE BEAMAN & DEAS DESTRUCTOR

This well-known type was one of the first three high-temperature systems evolved in Great Britain, and coming at a time when the old low-temperature destructors were prolific in nuisance, it became at once popular. The first installation was made at Warrington, where the results obtained in the production of a high temperature and also in high rate of combustion, or destroying capacity of the cell, were such as to greatly astonish many municipal engineers.

Even at this time the writer doubts whether any other destructor cell in the ordinary way is capable of dealing with so great a weight of refuse per twenty-four hours. Only a few months since a test at St. Helens with a Beaman & Deas destructor showed a rate of combustion of over twenty-seven and one-half tons per cell per twenty-four hours. In order to fully appreciate what this means, as compared with other modern high-temperature destructors, we have only to select two such well-known installations as those at Shoreditch and Fulham; in both cases ten tons per cell per twenty-four hours are the maximum

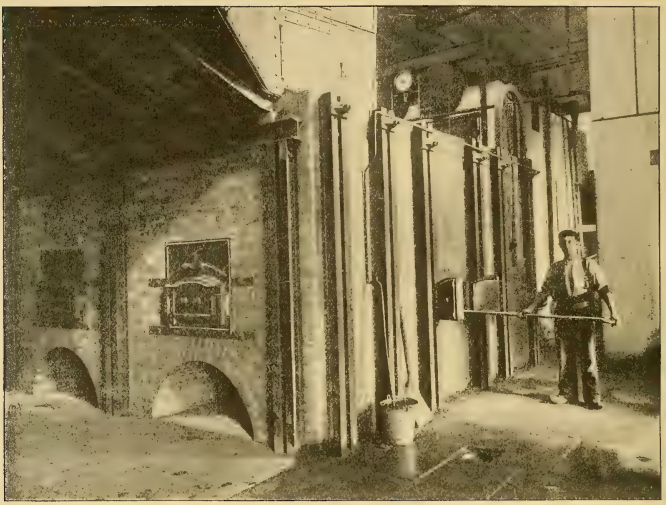


FIG. 20.—BEAMAN & DEAS DESTRUCTOR AT COLNE. INSTALLED BY MESSRS. MELDRUM BROS., LTD., MANCHESTER

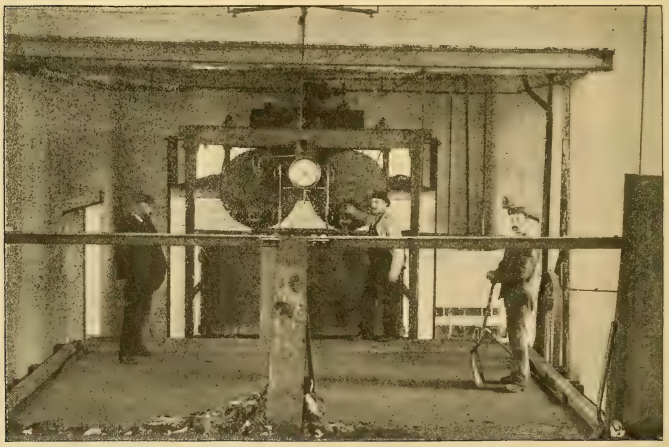


FIG. 21.—THE BEAMAN & DEAS DESTRUCTOR AT COLNE, SHOWING TIPPING FLOOR

quantity dealt with. The general working efficiency at St. Helens was not sacrificed in any way, even when the rate of combustion was so high.

The Beaman & Deas cell has a grate area of 25 square feet; the normal destroying capacity is fifteen tons per cell per twenty-four hours, which is fairly easy work; in most installations from eighteen to twenty tons per cell per twenty-four hours are being put through and reduced to a good vitreous clinker. In general design this destructor consists of two cells, each having an inclined drying hearth on which the refuse falls either from a storage hopper, charging chamber, or ordinary tipping floor, as the case may be. Placed between the cells is a common combustion chamber in which the gases collect and commingle; from there they are carried off through a steam boiler or by-pass flue as required. A Babcock & Wilcox water-tube boiler is set at one end of the combustion chamber.

In the ordinary way the carts shoot the refuse on to the tipping floor over the cells and a charge is fed through an opening on to the drying hearth as required. Another arrangement which is in successful use in a few later installations is what is known as the storage hopper and charging chamber. The carts tip the refuse direct into the storage hopper, which is well removed from the heat. Between this hopper and the charging chamber are placed doors, which can be opened from below as required to admit a charge of refuse into the chamber. There, again, a similar pair of doors are opened from below, and the material is at once delivered on to the drying hearth from which it is raked forward and levelled on the grate proper.

The general arrangement of a cell or pair of cells is such that the gases distilled on the drying hearth must pass over the hottest part of the fire; again, it is customary in working a pair of cells to so handle them that they are charged and clinkered alternately, so that at the time when one cell is newly charged, the other will be in full work, and the high-temperature gases from the latter will commingle with those from the former in the common combustion chamber. In this way a fairly uniform temperature is maintained in the combustion chamber. Forced draught is provided by high-pressure fans, usually steam-driven, the air supply being delivered through an underground air duct direct into the sealed ash pits.

All the firing, and clinkering doors and combustion chamber doors are placed close together, practically on one side of the installation, so as to be readily under control of the stoker. A specially constructed vertical damper is arranged on the top of each fire bridge, which is almost closed when the cell is being charged, so that only a small quantity of the gases distilling from the

TABLE V.—TEST OF HEENAN'S TWIN CELL DESTRUCTOR ERECTED FOR BLACKBURN CORPORATION.

Date of test	May 15th, 1901.
Duration	7 hours, 40 minutes.
Cells in use	4=2 twin cells
Total grate area	120 square feet.
Total heating surface of boiler	2,400 square feet.
Type of boiler	Heenan's patent water tube.
Total refuse burnt	31,692 lbs.
Total refuse burnt per hour average	4,159.8 lbs.
Total refuse burnt per square foot grate per hour	34.66 lbs.
Refuse burnt per cell per hour	1,015 lbs. or 9 cwts.,0 qr., 7 lbs.
Rate of burning capacity per cell per 24 hours	10 ts. 17 cwts., 2. qr., 0 lb.
Total clinker and fire ash	10,052 lbs.
Percentage of clinker and fine ash to charged refuse	25.5 per cent.
Temperature of combustion chamber	1,800 deg. Fahr.
Temperature at chimney base	700 deg. Fahr.
Temperature of feed-water in tank	59 deg. Fahr.
Temperature of feed-water after leaving exhaust steam heater	116.5 deg. Fahr.
Temperature of charging floor	70 deg. Fahr.
Temperature of clinkering floor	79 deg. Fahr.
Average steam pressure	122.3 lbs.
Total water evaporated	36,221 lbs.
Total water evaporated per hour	4,724.7 lbs.
Total water evaporated per hour square foot heating surface	1.96 lbs.
Total water evaporated per lb. of refuse actual	1.135 lbs.
Total water evaporated per lb. of refuse from and at 212 deg. Fahr	1.297 lbs.

TABLE VI.—TEST OF BEAMAN & DEAS DESTRUCTOR ERECTED FOR CANTERBURY CORPORATION TWO CELLS WITH A TOTAL GRATE AREA OF 50 SQUARE FEET, WITH ONE BABCOCK & WILCOX BOILER WITH 1619 SQUARE FEET OF HEATING SURFACE.

Quantity of refuse	dry and of average quality
Duration of test	8¼ hours.
Average temperature of feed	123 deg. Fahr.
Average boiler pressure	135 lbs.
Total refuse consumed	29,400 lbs.
Total water evaporated	41,280 lbs.
Water evaporated per pound of refuse (actual)	1.4 lbs.
Water evaporated from and at 212 deg. Fahr.	1.58 lbs.
Total refuse burned per hour	3,360 lbs. = 1½ tons.
Weight of refuse burned per cell per 24 hours	18 tons.
Refuse burned per square foot of grate per hour	67.5 lbs.
Water evaporated per hour average	4,717 lbs.
Percentage of residue or clinker	28.61 per cent.
Total weight of residue or clinker	11,536 lbs. = 5 tons 3 cwts.
Temperature of combustion chamber (by copper test)	2,000 degr. Fahr.

green charge can get into the combustion chamber.

Particulars of a test made at Canterbury are given in Table VI.

This test was the official test under Mr. Robert Hammond, M. I. C. E., M. I. E. E , the consulting engineer to the Corporation of Canterbury.

Two illustrations are given in Figs. 20 and 21, showing the Beaman & Deas destructor at Colne, Lancashire.

The subject of my remarks is such an important one that it is really a very difficult matter to give anything like a comprehensive review in the space here at disposal, but it is hoped that sufficient has been said to vindicate the power destructor and to prove the fuel value of refuse.

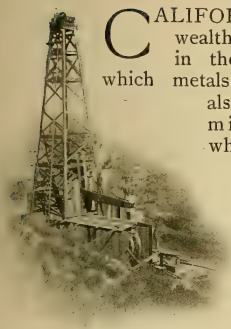
It is worth adding here that to-day British power destructors represent the world's best practice in this field of engineering. America, with its extraordinary enterprise, is left a long way behind, and the best destructor working in any American city to-day is not even equal to British productions of ten years ago. Precisely the same may be said of Continental practice, notwithstanding the fact that a number of "home-made" destructors on the Continent have been copied from standard British types.

Some will say that the different composition of the refuse is the explanation, but this is the case only to a limited extent. Many Continental and American destructors would be dismal failures with the best of refuse, simply because they are wrong in principle and crude in design.

Although Great Britain's position in this matter is so very satisfactory, let it not be thought that finality has been reached. There is yet room for improvement in detail which will tend to minimise labour and reduce the cost of destruction. The main principles are sound, and, therefore, they will endure: temperatures sufficiently high for all practical purposes are readily reached: nuisance is practically unknown; the clinker is vitreous and serviceable.

PETROLEUM IN CALIFORNIA

By W. L. Watts, E. M., of the California State Mining Bureau



CALIFORNIA'S mineral wealth consists not only in those minerals from which metals are obtained, but also in numerous other mineral substances, which become in greater demand as manufacturing interests expand and as civilisation advances. The most important of the latter class of minerals, which, in a commercial sense, may be regarded as non-metallic, are the hydrocarbons; and of these, petroleum, in the form of asphaltum, oil, and natural gas, are of the greatest value.

But it is only of late years that the importance of the petroleum interests of California have been recognised. Exclusive of asphaltum and gas, it is represented by the amount of foreign capital expended in the work of extracting and handling the oil, by the price obtained for that portion of the petroleum which is exported by California residents, and by the value of that portion which is consumed in California. The part consumed in the State constitutes the bulk of the petroleum output, and is used chiefly as fuel, thus becoming one of the leading factors in California's commercial economy.

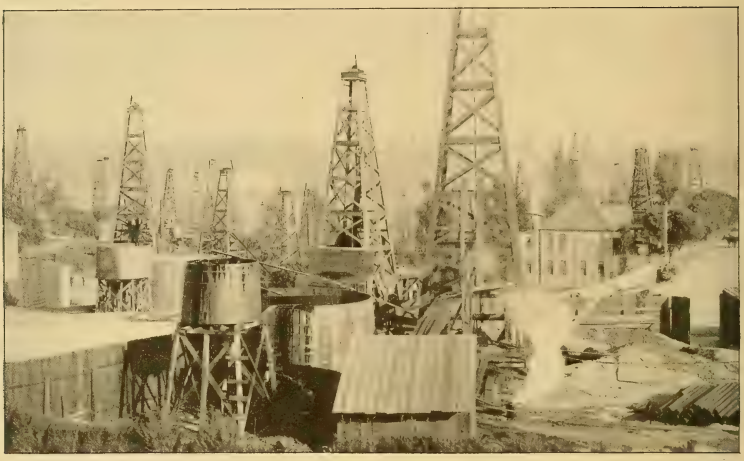
In California the question of petroleum as fuel assumes a special importance, owing to the fact that the deposits of coal thus far discovered in the State are inadequate to the steadily increasing demand for fuel, and this, coupled with the remarkable California petroleum "finds" of the past year, reminding one of the phenomenal early oil days of Pennsylvania, lends a timely interest to the following particulars, which were originally presented by the writer in an address to the American Institute of Mining Engineers.

The existence of petroleum in California has been known for many years. From time immemorial the California Indians used this mineral, in the form of asphaltum, for various purposes, and in the early history of the State the Catholic fathers utilised it for roofing their missions and other buildings.

It is said that in 1855 or 1856 Andreas Pico distilled petroleum on a small scale for the San Fernando Mission. He obtained his crude oil from Pico cañon, near Newhall, in Los Angeles County; and he was probably the first refiner of petroleum in the State. In 1856 a company commenced work at the La Brea ranch, in Los Angeles County, and tried to refine the crude oil. In 1857 an attempt was made to produce illuminating oil from crude petroleum at Carpenteria, in Santa Barbara County; and there are records of similar attempts in other localities previous to 1860, but none of them were successful.

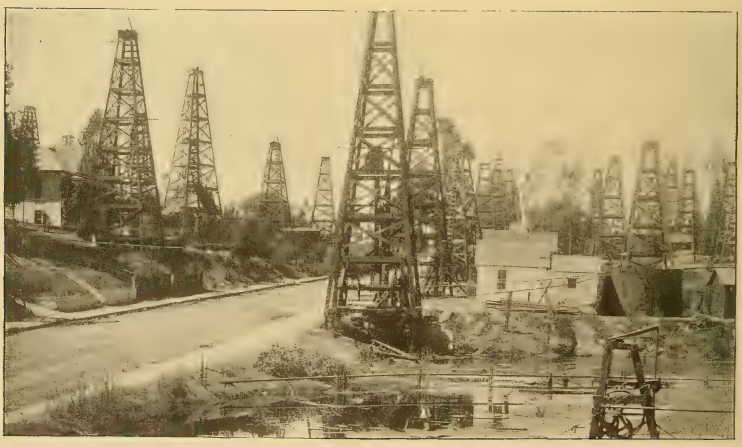
The first scientific report on petroleum in California was made by Prof. B. Silliman, who published his researches in 1865. He spoke favourably of the possibility of obtaining petroleum in remunerative quantities in the State, and gave the results of his experiments in the fractional distillation of California petroleum.

The next decade was marked by a considerable oil excitement in California, and a great many companies were formed for the purpose of petroleum mining and for distilling crude oil. In most instances these companies did not meet with success; but it must be re-



OIL WELLS AT LOS ANGELES

PHOTO BY F. L. PARK & CO., LOS ANGELES



ANOTHER VIEW, SHOWING OIL WELLS ALONG ONE OF THE TOWN'S THOROUGHFARES

PHOTO BY C. C. PIERCE, LOS ANGELES

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membered that the pioneer oil miners did not have the drilling machinery of the present day, and that they possessed a very limited knowledge of the geological conditions pertaining to the occurrence of petroleum deposits.

The pioneer distillers appear to have expected that by the fractional distillation of California petroleum they would obtain similar products to those resulting from the fractional distillation of the petroleum found in the eastern districts

THE OIL COUNTRY AT FULLERTON

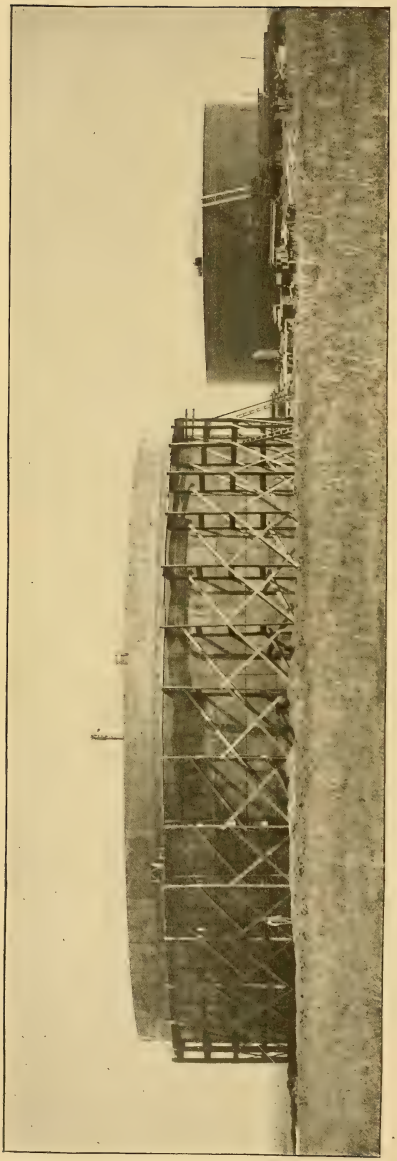
FROM A PHOTO BY C. C. PIERCE

of the United States, but they were disappointed. It is not surprising that, in the course of years, the smaller operators became merged in larger concerns. In 1887, when the California State Mining Bureau made a reconnaissance of the petroleum industry of the State, the only companies actually engaged in petroleum mining were:—The Pacific Coast Oil Company, in Pico cañon, and the Puente Oil Company, in the Puente hills, Los Angeles County; the Hardisson & Stewart Oil Company, subsequently incorporated as the Union Oil Company, of Ventura County, and McPherson & Co., operating in Moody Gulch, in Santa Clara County.

The first refinery that could be considered a commercial success was that of the Californa Star Oil Company, situated near Newhall, in Los Angeles County, and managed by T. H. Scott. Subsequently, refineries were erected at Alameda by the Pacific Coast Oil Company, and at Santa Paula by the Union Oil Company. At the present day there are refineries at Los Angeles, Chino, Ventura, and Alameda, also at Oleum, in Contra Costa County, to which place the refinery of the Union Oil Company was removed.

During the last decade there has been a steady increase in the amount of petroleum produced in California and in the amount of oil territory developed. In 1889 the output of petroleum for the State was 303,220 barrels; in 1898 it was 2,249,088 barrels, an increase of more than sevenfold. Since 1898 the output has made phenomenal advances.

The California petroleum is found in formations which range from the lower



A FIFTY-THOUSAND-BARREL STORAGE TANK
FROM A PHOTO BY TROST

cretaceous to the quaternary, the greater portion being in the eocene and the neocene formations. In this State it is imperative that oil-mining operations should be governed by a careful study of the structural geology of the locality in which they are conducted, for wherever petroleum has been found in California, geological disturbance has complicated the stratigraphic conditions.

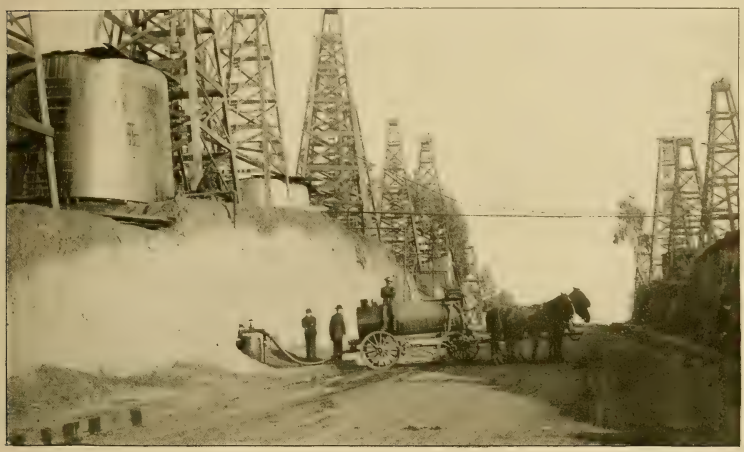
To those who explore the hills and mountains of the Coast range there are few things more interesting than the curiously folded condition of the rocky strata. In California the student of structural geology has not to search very far before he finds natural illustrations of the types of folds he has seen in his text-books. In some parts of the world such folds are many miles in breadth; but in the Coast range the conspicuous folds are generally narrow ones. The small and conspicuous folds usually constitute portions of larger folds, which, although they are more important than the small folds in the formation of hills and mountains, are not so easily detected, unless a large area is carefully mapped out and studied. The small folds are, however, of great importance in determining the course and the width of "oil lines."

It is reasonable to suppose that the compressed folds do not extend to a great depth in a uniform curve, but that the rock masses have been readjusted by reciprocal movement. Wherever there has been so much geological disturbance as is the case in the Coast range, it is evident that structural conditions must be modified, not only by faults and fissures, but also by the

thinning or thickening of the softer strata by reason of the compression to which they have been subjected. When the outcrop of the oil-yielding stratum can be found, it constitutes a most important guide to the prospector. A careful observation of it shows the horizontal direction in which the oil sand extends and the angle at which it is inclined. From the latter factor the depth at which the oil sand can be struck by drilling at any given distance from the outcrop can be calculated. But it frequently happens that the oil-yielding stratum does not crop out at the surface of the ground. In such cases its dip and strike must be inferred from any of the rocks enclosing it which may be exposed, provided, always, that the oil sand and the enclosing rocks are conformable. In California it frequently happens that, within a limited area, the exposed strata show a great diversity of dip, and the best guide as to the prevailing strike of the formation is the strike of the axis of the fold into which the strata have been thrown.

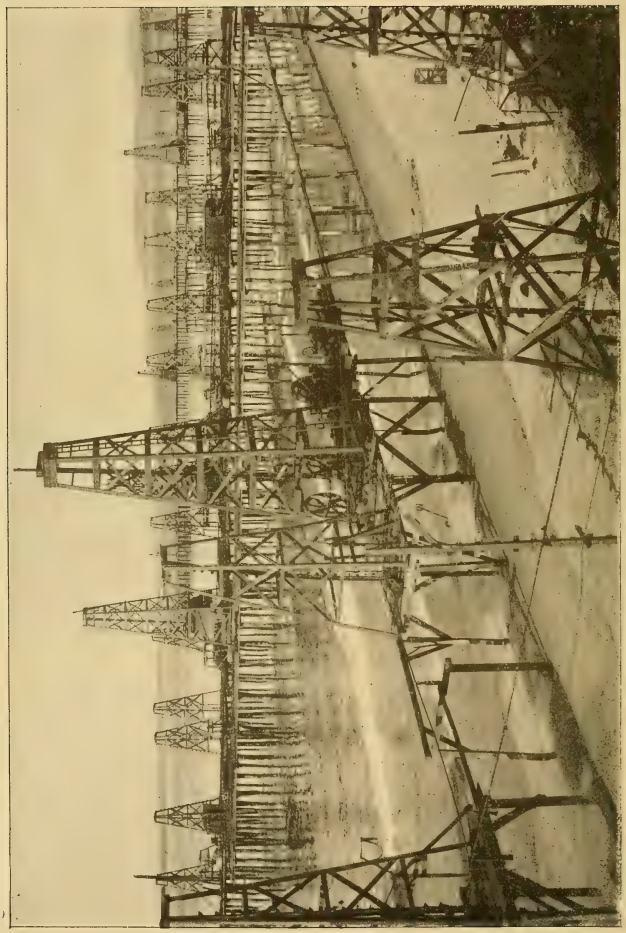
When the exposed rocks are situated near the axis of a fold, or when the fold of which they form a part is overturned, they are by no means an infallible guide as to the prevailing angle of the dip. In locating an oil well, the character of the fold affecting the rocks about to be prospected should be taken into account. There are conditions of the rocky strata, besides those of folding, which may determine the existence and the course of oil lines, and the most important of these are faults. The class of faults most likely to result in the formation of oil lines are those which have been caused by fractures extending in the direction of the strike of the formation, and which have allowed blocks of the earth's crust to slip past one another so that they are arranged in the form of steps. In areas of great compression, like that of the Coast range, it might be supposed that all the faults would be thrust-faults, but in many instances the fracture which occasioned the fault is nearly vertical to the plane of the horizon,—in which event it is frequently the case that the force of gravity controls the thrust.

The California oil fields which have as yet been developed are situated in



FILLING AN OIL WAGGON

PHOTO BY F. L. PARK & CO.



OIL WELLS ALONG THE BEACH AT SUMMERLAND, CALIFORNIA

PHOTO BY FRANK I. PARK & CO., LOS ANGELES

Los Angeles, Ventura, Santa Barbara, Kern, Kings, and Fresno counties. Oil-yielding formations have been traced throughout the Coast range almost from San Diego to Del Norte counties. North of San Francisco no oil fields have as yet been developed, but prospect wells are being drilled at several places.

The most remarkable features in the recent history of the petroleum industry in California have been the development of the Los Angeles oil field, the Summerland oil field, in Santa Barbara, and the oil field of Coalinga, in Fresno County. The Coalinga oil field is the most important yet developed in the border of the central valley of California. It is remarkable both for the amount and the quality of the oil which it has produced. Very productive oil fields have also been developed at the Kern River and at McKittrick, in Kern County.

In the Los Angeles oil field fully 1100 wells have been drilled within an area of about two and one-quarter miles in length and less than a quarter of a mile in width. Moreover, a western extension of that oil field has since been developed about a mile to the westward of what has heretofore been known as the Los Angeles oil field. The first portion of the oil field developed was at Second Street park; and the discovery that oil existed there in valuable quantities was due to the enterprise of a firm of contractors, who commenced operations by sinking a prospect shaft, 155 feet deep, at one of the street intersections. The way in which a forest of derricks grew up, as if by magic, and a district of quiet residences was transformed into a mining centre, is a matter of history.

The Los Angeles oil field, developed, as it was, in the midst of a city, is in itself a remarkable incident in the history of oil mining. Furthermore, it gave an impetus to the petroleum industry in California, which within a few years caused the industry to rise from a position of comparative insignificance to one of great importance.

The formation penetrated by the Los Angeles oil wells is a shale containing strata of oil-yielding sandstone.

The direction in which the western extremity of the oil line had been developed caused grave apprehensions lest it might invade the more expensive residence portion of the city and mar some of its beauties. Those apprehensions, however, were happily not realised. As is well known, the petroleum found in the eastern parts of the United States is composed principally of hydrocarbons of the paraffin series. Investigations hitherto made on the petroleum found in California have shown that they are composed principally of hydrocarbons containing a greater percentage of carbon than do the corresponding members of the paraffin series. It is this excess of carbon that causes the difficulties experienced in manufacturing from the California petroleum illuminating oils which can successfully compete with illuminating oil manufactured from Eastern petroleum.

Although only a small portion of the California petroleum is available for the manufacturing of illuminating oil, it can be resolved into other valuable commodities. It yields naphthas, gas distillate, lubricating oil and asphaltum. The greatest value of California petroleum is that it furnishes an excellent fuel. Repeated tests have shown that, for fuel purposes, from two and a half to four barrels of crude petroleum may be taken as the equivalent of one ton of good coal, the ratio of value differing according to the conditions under which the petroleum is burned.

The use of petroleum as fuel in California certainly dates as far back as 1878. Although its superiority to solid fuel has been demonstrated for more than twenty years, it has only recently commenced to crowd out the black diamond from the railroad and the workshop. When it is considered that large sums are annually expended by California for imported coal, and that the substitution of petroleum for coal would result in the expending of this money on a home product, the importance of the petroleum industry to California can be appreciated.

FORCED DRAUGHT

ITS ADVANTAGES COMPARED WITH CHIMNEY DRAUGHT

By William H. Booth

TO gain clear ideas on the subject of forced draught it is first necessary to know what is understood by an ordinary or so-called natural draught. Natural draught is that produced by a chimney. Stated in brief, a chimney is simply a casing built round a column of heated air, and serves to protect such column from intermingling with the surrounding cold air. The only openings to a chimney are, or should be, at each end of it; that at the top allows the warm air to escape and that at the bottom allows the cold atmosphere to flow in. Left to itself, the inflow would continue until the inside of the chimney arrived at the same temperature as the outside. The flow would then cease and would recommence upwards or downwards only as the natural temperature fell or rose. In the latter case there would be a down draught,—that familiar domestic nuisance that will occur when a hot day rapidly succeeds colder weather.

A cold chimney then produces this down effect. Chimney draught is thus caused by the superior weight of a column of the outer air above the weight of a column, of equal height, of the hot air enclosed in the chimney. The action is made continuous by building a fire in the passage that admits the atmosphere to the lower end of the chimney. In this way the inwardly pressing cold air is heated and the chimney is kept constantly warm. By so arranging the air-warming apparatus that the air must pass through a grate on which the fire is carried, we promote the rapid combustion of this fuel, and produce so much heat that most of it may be employed to produce steam, and yet there will always be sufficient heat left to produce a considerable draught.

The reason why draught is produced is simple. A cubic foot of air, or any other gas, at the temperature of zero degrees C. (32 degrees F.) is increased in volume $\frac{1}{273}$ for each additional degree of temperature centigrade, or about $\frac{1}{491}$ for each additional degree Fahrenheit. Thus, by heating the air to 273° C. (or 491° F.), it will be doubled in volume, and, of course, one cubic foot will then weigh only one-half as much as before. Thus the air outside a chimney, if heated to the extent stated, will have a pressure to force it through the fire just double that which the hot gas in the chimney will possess.

It is a fallacy to suppose that a chimney has any sucking power. Chimneys act purely because the external air is heavier than that inside the chimney, and the heavier air simply tumbles into the chimney through every available opening. As this flow is caused by the difference of weight of two columns of air of the height of the chimney, it is plain that the highest chimney will show the greatest difference and produce the best draught.

Having once constructed a chimney, it will always give a draught having the intensity proper to, and consequent upon, its height. Its power will never vary, excepting only from causes external to itself. Thus, a variation in the temperature inside or outside will

increase or diminish the draught. The weight of water vapour is little more than half that of air. When there is a fog, the air is largely replaced by water vapour, and the draught intensity of a chimney is diminished.

The amount of fuel that it is possible to burn upon a given area of grate is dependent upon the intensity of draught. With a chimney of 200 feet, about twenty-one pounds of coal can be consumed per square foot per hour. There is a close connection between draught and fuel consumption and economy. If the draught is poor, it will be found necessary to spread the fuel in thin layers upon the grate, and experience teaches us that when the fire is thin very large volumes of air pass into the flues without combining with the fuel. This excess of air is not merely useless, but is actually pernicious, because it lowers the temperature of the chimney and aggravates the very evil of poor draught that gave rise to the necessity of the thin fire. The evil is thus cumulative.

It is well known that the load upon an electric light station is subject to very wide and very rapid fluctuation. The demand for steam is small one minute, and in a very brief time attains a maximum. The rapid darkness that sometimes comes over a city, caused by a fog or thunder storm, is one of the most potent causes of rapid load fluctuation. The mischief is twofold. Not only does the fog increase the demand for light to a rapidly acquired maximum, but it diminishes the intensity of the draught and prevents the rapid combustion of fuel at the very period when this is most necessary. It is not surprising, therefore, that electric lighting has given a considerable fillip to the question of mechanically produced or forced draught as distinguished from natural draught.

A forced draught is one that is intensified by other means than the chimney. The most familiar example is the locomotive. The chimney of a locomotive is so very small in height that the natural draught is of no useful account whatever, and the draught is therefore produced by a rapidly moving jet of steam directed upwards into the chimney with such force as to push away the atmosphere to some extent and allow a free rush of air through the fire, the gases from which, as soon as formed, are blown out at the chimney by the steam jet. In practice this steam jet is provided by the steam that has already done duty in the working cylinders, from which it is ejected with sufficient remaining energy to produce the necessary draught.

With such a draught, coal can be burned at ratios of 100, 120 or 150 pounds per square foot of grate area per hour. The thickness of the fire may be considerable, because there is ample power of flow, and less of the air that passes through the fire will thus escape uncombined with carbon. There is thus produced a higher temperature in the furnace, and economy results. This part of the subject will bear dwelling on.

Under ordinary conditions of combustion, one pound of fuel will be accompanied by about twenty-four pounds of air. The minimum quantity actually and chemically necessary for complete combustion is between eleven and twelve pounds. The temperature in the furnace may be 2400° F. That in the chimney may be 600°. Approximately, therefore, one-fourth the heat produced is escaping at the chimney. If, however, the air supply could be cut down to eleven and one-half pounds per pound of fuel,—that is to say, to the chemical minimum,—and the temperatures were still maintained the same, it is clear that the amount of heat now going up the chimney would be only one-half what it was before, and an economy of one-eighth of the fuel would be secured. In practice, with forced draught the temperature in the furnace would be greater and that in the chimney would be less than with natural draught, and there would be less weight of gases flowing away and the economy would be better than indicated.

The gases escaping at a chimney can never be cooled so low as the boiler to

which they impart their heat. There must always be a considerable difference of temperature. Hence has arisen the custom of exposing pipes full of cooler water to the waste gases in the flue beyond the boiler. The temperature of a boiler internally may be 350 degrees F., and that of the chimney 650 degrees. If, now, the cold-water pipes, or economisers, as they have been termed, have a temperature of 150 degrees, they may cool down the gases passing by them to 350 degrees, and thereby save the heat represented by the difference of 200 degrees F. Such appliances do prove economies, but they offer, at the same time, a considerable resistance to the flow of the gases to the chimney and thus diminish the draught. By means of a series of such economisers, filled with successively colder and colder water, the gases might finally be turned into the chimney at so low a temperature as to be incapable of producing any serious draught whatever.

Were this ideal attainable commercially, it would suffice simply to blow air into the furnace by some mechanical means, or to draw it out and blow it away at the chimney. Such means would then draw the furnace products through the numerous cooling obstructions placed in the flue and would deliver the cooled gases to the chimney, now useless, except as a means for carrying the objectionable gases some distance above ground in order to place them where the ordinary atmospheric movements could complete their disposal. It is obvious that a fan, to accomplish this, would require a certain amount of power. The economies of the case thus demand that an equation be made between the first cost of the chimney and of the fan, or other artificial draught producer, and between the cost of working the chimney and of working the fan. There also comes into account the cost of such apparatus as is necessary to cool the gases so as to secure the economy due to the abstraction of their heat.

In an ordinary case we have seen that the chimney may absorb one-fourth of the total power of a boiler. Thus, in a plant of 1600 H. P. there may be obtained 1200 H. P. at the engine and 400 may be sent up the chimney. It thus costs 400 H. P. to produce draught for 1200 H. P. net. By the use of a fan and the addition of feed-water heaters the amount of excess of air may be reduced, say, from twelve pounds to six pounds. This represents an economy of about 100 H. P., for there are now eighteen pounds of air going up the chimney per pound of fuel consumed in place of about twenty-four pounds. Of the 300 H. P. still going to waste at 600 degrees F. it is now possible to save another 100 H. P. by the use of special cooling devices. In all, 200 H. P. have been saved.

A well-designed fan is claimed to run with about 1 per cent. of the power of the engines supplied by the boilers. Thus, the fan in this case would absorb 12 H. P., leaving a net saving of 188 H. P., or about 16 per cent. Even if the additional cooling surface is not provided, the use of a fan admits of so much economy of air supply to the furnace that the first 100 H. P. saved may be relied upon. This is secured as the result of the thicker fires which it is now practicable to employ and whereby less excess of air may be used. The figure quoted, eighteen pounds of air, is by no means a minimum. With good chimney draught, the air supply, with thick fires, has been reduced to below fifteen pounds per pound of fuel.

But these are not the only advantages. Of equal importance is the increased efficiency of service rendered possible. Almost simultaneously with the sudden demand for more steam, the fires that have been quiescent may be urged to full vigour and the maximum steam production of a boiler may be obtained simply by urging the fan to a higher speed. Almost as rapidly this output can be reduced to a minimum as the passing of the cloud, or the fog, or thunder storm reduces the abnormal demand for light.

Very economical results can be secured from steam boilers with low rates of combustion per square foot of grate surface, and yet these rates may

be very largely augmented without serious loss, or even with a gain in certain cases. As already stated, a poor draught can be made to burn coal freely only when the fuel bed is thin and open, and very large volumes of air are then admitted in excess of true requirements. With a more powerful draught, the combustion may be kept brisk even when the fire is thick. This enables combustion to be effected by the use of very much less air than is possible with a poor draught. As a rule, for general practice it may be laid down that the best economy is secured when the fuel thickness is the maximum that can be worked by the draught available without excessive stirring or slicing of the fire, and that when the thickness has been found, the grate area must be cut down to that necessary to burn the fuel requisite to produce the required steam, provided, of course, that there is some margin of draught still available for heavier demands for steam to cope with the peaks of the load.

These results can be secured only by means of mechanically produced draught. The steam jet may be dismissed with the remark that it may be cheaply applied to produce draught, though it is costly to work. Steam jet furnaces, however, show an over all economy because the jet enables cheap fuel to be employed, and may thus save more than it costs. Positive blowers are useful to blow smelting furnaces because they will give very high pressures. They are not suitable for steam boilers. The best appliance for steam boilers is the fan. The action of a fan is simple. As it revolves, its vanes carry with them the air that surrounds them, and as this air, when in motion, tries to move in a straight line, it will leave the casing in which the fan revolves by any tangential opening there may be. Air to fill its place enters at the eye of the fan, and, in turn, travels by a special path until it also escapes tangentially with a velocity impressed on it that is approximately that of the fan tip. Clearly, therefore, the tip of a fan must move at such a speed as will produce the velocity of air flow that would be given by a draught of the intended intensity.

Assuming that the draught is to have an intensity of one inch water gauge, what must be the velocity? The laws that govern the flow of gases are the same as those for liquids. Velocity of flow depends upon the height of the column equal to the pressure. Thus, at ordinary atmospheric pressures and temperature the pressure on a square foot is 2115 pounds. A cubic foot of air weighs 0.07788 pound. If of equal density throughout, a column of air at atmospheric pressure per square foot of area must, therefore, have a height of $2115 \div 0.07788 = 27160$ feet. The formula for fluid flow is $v = \sqrt{2gh}$.

The column of air would thus flow into a vacuum at a velocity per second equal to $\sqrt{64 \times 27,160}$, or about 1320 feet. Now a pressure of one inch of water is equal to 0.578 of an ounce per square inch. As an atmosphere of pressure is 235 ounces per square inch, it follows that 0.578 ounce is $\frac{1}{406}$ of an atmosphere, or, say, 66 feet. The velocity due to a head of 66 feet is thus $\sqrt{64 \times 66}$, or about 65 feet per second. With a chimney draught, a flow of 30 feet per second is looked on as a minimum for smoke prevention. Double this would thus be a very fair draught.

The usual formula for draught velocity is $65.5\sqrt{H}$, where H is the water gauge developed in inches. The power to drive a fan increases as the cube of the velocity. Obviously, therefore, the speed of a fan must not exceed that proper to the desired draught. In other words, it is very uneconomical to use a small fan driven at a high speed in order to obtain a large volume of air. The current practice is to employ a fan of sufficient size to give the air volume required at the minimum pressure. The fan tip must revolve only at such a velocity as will give this pressure.

Artificial draught by fans may be employed in three distinct ways. These are the close stokehold, the closed ash-pit, and the induced methods. In the first, which is rarely, if ever, met with unless on board ship, the boilers are

placed in an airtight chamber. The fan delivers air into this chamber and the only outlet is through the furnaces, which are urged to a high intensity by the power of the draught. In this system, when a fire door is opened for stoking or other purpose a check damper should be closed so as to prevent the air rushing too freely through the boiler to the chimney.

In the closed ashpit system air is blown below the grates, and there are openings for its admission also above the fuel. Care is needed that flames are not blown out at the fire-door when the chimney damper is closed. The system has been very successfully used at sea.

The system *par excellence*, however, for land purposes is the induced system, in which a fan takes the place of a chimney and draws the products of combustion away from the boilers and delivers them to a chimney that need not have a height above 30 to 50 feet, according to environment. A fan draught thus applied is something more powerful, as a rule, than a good chimney draught. It has the advantage, however, that it may at once be increased or decreased in intensity so as to cope with whatever variable demand there may be for steam. As applied in practice, the fans are usually of simple radial-blade type, revolving in a steel-plate casing with water-cooled bearings for the fan spindle. The inlet to the fan is at one or both sides, and the outlet is as desired. Frequently the fan delivers upwards into a light chimney that stands upon the fan casing, or the fan casing may be partly built of brickwork with an upper portion of steel plate.

Fan draught is not merely useful in making a power plant better able to cope with a variable duty, but it is also more economical to lay down and maintain than is a chimney draught plant. In a plant of 2400 horse-power it has been estimated that the first cost of a chimney and damper apparatus will be about £2200. The same duty, with capacity for extra effort, can be had from a fan apparatus costing, complete, about £940, thus effecting a saving of £1260. This estimate supposes that the rate of combustion is maintained alike. But if fuller advantage be taken of the better draught, the boilers rated at 2400 H. P. might be reduced in power to about 2000 nominal rating.

A better draught and thicker fires would be employed and the volume of air per pound of fuel consumed would be thereby reduced. An additional saving can thus be made of about one-sixth the cost of the boilers. These would cost about £7500 with chimney draught, and about £6200 with the fan. There would thus be a further saving in the reduced size of boiler house necessary. The total estimate of saving is £2700, approximately, in first cost alone, part of which might well be expended in additional economiser surface, if desired, whereby a still further reduction of boiler capacity might be allowable.

One of the most useful applications of fan draught is to augment the capacity of existing boiler plant. The plant may perhaps have been added to until it is entirely beyond the capacity of the old chimney, and the draught is poor and sluggish. At once the boiler fires can be brightened up and one or two boilers perhaps laid off as spares simply through the aid of a fan. Economy is secured in first cost and it is secured in better combustion with less air, but more should still be sought.

A chimney obtains its power by virtue solely of its internal high temperature. It is computed that under ordinary conditions an internal temperature of 500° F. will produce as good a draught with a chimney of 100 feet as would be produced by a chimney of 175 feet with an internal temperature of only 250°. With a fan this is reversed. The cooler gases demand the smaller fan. It is productive of a double effect to add further economiser surface because the waste gases are further cooled thereby and the fan action is improved. With a chimney, the addition of more pipes to the economiser system reduces the draught and puts in resistance to the impoverished draught.

It has been found as the average of

nine plants that the gases left the economisers at 270°, and that the economisers showed 14.64 per cent. of economy. If desired, the gases rejected by the economiser may still be used to warm the air passing to the boiler fires with further economy. In the writer's own experience it would appear that the use of economisers has tended to the use of chimneys of larger capacity than where no economisers are employed, as might be expected. By raising the intensity of combustion and reducing the air supply, the total air passing to the chimney should be considerably reduced with fan draught. This greatly enhances the value of the heating surface of both boiler and economiser. The better draught reduces smoke, and is a powerful tool in the hands of the skillful stoker.

There is a further economy possible with fan draught that may commercially surpass all other economies. This is the ability to burn inferior fuels, the calorific capacity of which is much greater than their price. Some of the worst coals have three-fourths the calorific capacity of the good coals, but cost less than half as much, while they will produce double as much steam per unit of cost.

Experience points out, as already stated, that the power necessary to drive a fan is only about one per cent. of the power necessary to drive the main engines supplied from the same boiler. The production of fan draught is not a costly process. A few more figures of temperature may be of interest. From a large number of tests made by the writer on the steam plant of large factories, it appears that the temperature of the gases entering economisers varied from 280° to as high as 765°. The outlet temperature was from 48° to 320° lower, the maximum temperature being 600° at the outlet to the chimney and the minimum, 260°. The feed was raised in temperature a maximum of 187° and a minimum of 2°, the highest temperature attained being 280°, the averages of forty cases being, —

Gas inlet	555°.	Outlet	377°. Fall 178°.
Water inlet	94°.	Outlet	200°. Rise 106°

A fair example was that of three large Lancashire boilers with 320 economiser pipes. The gases were reduced from 685° to 380°,—a fall of 305°, while the feed was raised from the hot-well temperature of 98° to 285°,—a rise of 187°. Usually the provision of about ninety-six pipes per Lancashire boiler would raise the feed-water 156° to a temperature fully half that of the escaping gases. Better results were sometimes secured, while the bad results were plainly caused by neglect and careless working. As the gases still escape at 350° to 400°, which temperature at least is necessary for draught purposes, it is obvious that with a fan, a less excess of air, a higher initial temperature, and a greater heat-absorbing surface per pound of waste gases, the final temperature may be still lower, especially if an additional water pipe surface be added in series with existing feed heaters.

Tests made by Mr. W. R. Roney on fan-draught plant may be compared with the above. He found the gases to enter at 526.3° and to leave at 269 6°, with a loss of 256.7°, while the water was heated from 150.4° through 146.7° to 297.1°. The heat lost up the stack in seventeen cases where no economiser was used was found by Donkin to be from 9.4 to 31.8 per cent of the total heat of combustion. Many small fuels are every bit as good as large coal, in calorific value, but are so very much more difficult to burn that they command very much smaller prices. It is almost always the case that the price of a fuel is regulated by size rather than by calorific capacity.

Mr. W. B. Snow has drawn comparisons between an American coal having an evaporative capacity of 11.04 and a Nova Scotian culm of 8.42 capacity, the ratio being 100:76. But the cost was as 100:53.3. The cost of evaporating 1000 gallons was thus found to be as 0.1698 to 0.1187, the commercial ratio being 100 to 156. But the low-grade fuel cannot be burned except with either excessive grate area or better draught. The use of the fan here would enable an economy of 56

per cent. to be realised apart from the further economy of better utilisation of the heat.

A fan-draught system will not give satisfaction if badly designed. As already stated, a fan must give its maximum support without being run at a peripheral velocity greater than that necessary to produce the air pressure desired. It must be large enough, and must discharge into a large pipe with easy bends, if any, and without sudden changes in area, while it may, with advantage, be tapered larger to its outlet and finished with an evasé chimney,—not a difficult matter with a chimney of 40 feet.

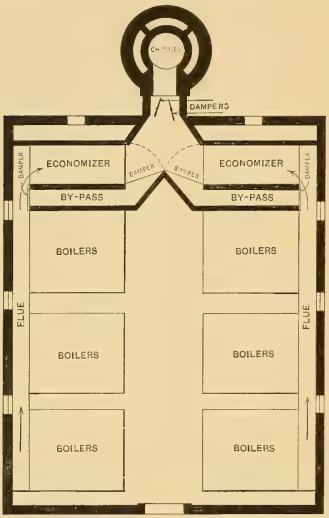


FIG. 1.—A COMPACT CHIMNEY-DRAUGHT DESIGN

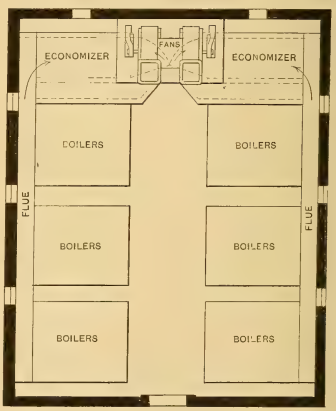


FIG. 2.—THE SAME PLANT, WITH FANS INSTEAD OF A CHIMNEY

Further ideas on the power absorbed may be derived by actual calculation. Let a plant of 1000 I. H. P. be considered! Such a plant on steady load will perhaps consume 2 pounds of fuel per H. P. per hour, or a total of 2000 pounds per hour, equivalent to an average of, say, 34 pounds per minute. Each pound of fuel ought not to require more than 15 pounds of air, but, to be well on the safe side, the total gases shall be figured as twenty times the fuel weight, or 680 pounds per minute. The duty of the fan is, then, to raise these gases to a height of, say, 50 feet. Then $680 \times 50 = 34{,}000$ foot-pounds of work done. This is just over one horse-power. If the fan has an efficiency of only 20 per cent., the power consumed would be only 5 H. P., or one-half of one per cent. of that of the main engines. It may then be fairly claimed that in a well-proportioned case the power will be under 1 per cent. The total work may be otherwise calculated as follows:—

With a draught of one inch of water gauge, the pressure per square foot is $5\frac{1}{4}$ pounds nearly. As one cubic foot of furnace gases at inlet temperature weighs about 0.05 pound, a column of gas 680 pounds in weight will have a length of 13,600 feet, and this is propelled by the fan at $5\frac{1}{4}$ pounds resistance. Thus, $13{,}600 \times 5\frac{1}{4} = 71{,}400$ foot-pounds, or two and one-sixth H. P. At 25 per cent. efficiency the total horse-power is thus nearly 9, or again under 1 per cent.

Attention may now be given to the

economy to be secured by a better utilisation of the heat of the fuel. By means of a fan to improve the draught it has been shown that thicker fires and better combustion with less air are possible, and with every pound of air saved, so much less heat has been thrown to waste, while the ratio of waste gases to heating surface has been improved. This economy alone is worth the expense of the change to fan draught. But it is well known that with natural draught the economiser to heat the feed cannot be used except with good chimneys or very low rates of combustion. In most cases the economiser can be fed with water at 100°. By now heating the water to 200°, an economy of 9 per cent. is secured. At 300° the economy is 22 per cent. If the feed is originally colder, the economy is still greater. Thus, a feed at 60° will, if heated to 200°, be 12 per cent. more economical. At 300° it saves 26½ per cent.

Fan draught enables this economy to be secured where there is no economiser yet established, for the economiser can be put in often in the room hitherto occupied by the old chimney. It enables an existing economiser to be extended, and it also makes economiser surface more efficient because the ratio of the weight of gases passing over a unit of surface of the pipes has been improved. Finally, there is always likely to be room for such an extension of economiser surface, as in all cases there is the chimney to be abolished, and where there are several boilers one of them can be displaced to make room for the economiser. No matter from what point the subject is approached, economy is visible.

But apart from economy there is a further incalculable advantage. In a new plant, say, for a tramway or for town lighting, it is often most difficult to forecast the ultimate extension, and the designer is face to face with one of two difficulties:—He must either build a chimney very much too large and, by so doing, entail a perpetual interest charge on the establishment, should the growth of business not justify the expense; or he must build a small chimney with its moderate draught and quickly find that he has insufficient power to meet the second year's demand, with every added boiler reducing the draught, already too small. He has then to build a second chimney and to extend his plant, with the first chimney blocking the way to the best arrangements and involving a heavy expense in flues, dampers, and by-passes. Had he commenced with a fan, he could have either put in a second fan, speeded up the first one if it had been wisely put in large and slow, or sold the fan plant to some newly started station and put down a fresh plant.

A chimney is a perennial expense. It cannot be sold separately from the works; it cannot be enlarged in diameter; and often, if raised in height, it gains very little, and looks disproportionate and ugly. The one difficulty with the fan is in starting up when all is cold, as it requires a long time to get up steam with a small sheet-iron chimney. Where a supply of electricity is not at hand to enable the fan to be set to work without steam, a gas-engine or an oil motor of small size may be put down for the purpose; or where electricity is at times available, a secondary battery affords means of driving the fan while steam is being got up.

The use of heated air has not been a great success in steam boiler work. The reason for this is that the enlarged bulk of the air does not admit of the introduction of it in sufficient volume to the fuel because the velocity of inflow must be increased. With a fan draught such velocity can be secured if desired, and if a hot air supply is anywhere available, the fan enables it to be used on the Howden system of closed furnace front. A further economy may, it is claimed, be secured in this way. Air can be heated by the waste gases as they are drawn to the fan. A large area of heating surface is necessary, and no doubt the fan efficiency would be increased by the still further cooling of the waste gases. It is, perhaps, doubtful if the total economy is worth the expense, and it is also probable that

air could be best heated by a modification of the hot blast stoves of the blast furnace, the air and waste gases passing, in turns, through two separate chambers of honeycomb work, the bricks in which alternately absorb heat from the furnace products and again give it up to the air.

A fan draught cannot render a boiler smokeless which is constructed on wrong principles, but there are many smoke cases which might be much improved. The Lancashire boiler can usually be worked smokelessly if the draught is good, but it will not work smokelessly if the draught is less than about 30 feet per second. This is a draught that can always be increased very easily with a very moderate application of the fan, and bituminous fuel can thus be employed when its use would otherwise expose the men to repeated fines.

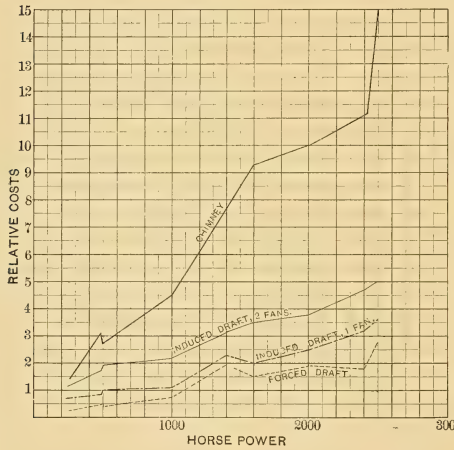


FIG. 3.—RELATIVE COSTS OF CHIMNEY AND FAN DRAUGHT

As the fan is known not to have a very high mechanical efficiency, it has been asked why should not the draught be furnished by a blowing engine or some such positive means as are used to blow the blast furnace. This question may best be answered by an appeal to figures. We will assume a large factory, consuming one ton of coal per hour. There will be required about 200 cubic feet of air per pound of fuel, or, say, 408,000 cubic feet per hour. Assume that the blowing engine is double-acting and runs at 100 revolutions per minute. Its cylinder must have a capacity of about 40 cubic feet; that is to say, the diameter would be 7 feet and the stroke would be 6 feet, and it would be difficult to build so huge an air blower in so light and unsubstantial manner as would alone warrant it being used in place of a fan. If used to pump the waste gases from the boiler it would have to be some 50 per cent. larger still on account of temperature. Moreover, the pressure sought is not such as to be suitably generated by a piston blower.

If the power required to drive a fan was a really serious quantity, a more efficient blower could be made by means of water-sealed bellows in the shape of rising and falling holders like small gas holders. But the complication of such a system is not worth incurring in face of the simplicity of the fan and the really trifling percentage of the total power that is employed to drive it.

As an example of dimensions and proportions a few figures may be given of the fans used on the American Line steamship *St. Paul.* This ship has twin screws, each driven by a six-cylinder quadruple-expansion engine with two low-pressure cylinders, 77 inches in diameter; intermediate cylinders, 55 and 77 inches, respectively; and two high-pressure cylinders, 28½ inches in diameter. There are six double and four single-ended boilers, 15 feet 6 inches in diameter and about 20 feet and 10 feet long, respectively. The total grate surface in the sixty four furnaces is 1144 square feet, burning about twelve and one-half tons per hour. The furnaces

are arranged in four stokeholds, each supplied with air by two 80-inch fans, the engines driving each fan being two-cylinder, 8″ × 5½″, direct-connected. They force the air through heaters in the up-takes into the fire-door casing on the Howden system. It is claimed that by heating the air, not only is the furnace temperature raised by the same amount, as might reasonably be anticipated, but even to a greater amount, because of the improved combustion.

Of the accompanying illustrations Fig. 3 represents a diagram by Mr. W. B. Snow to show the relative cost of chimney and mechanical draughts for horse-power up to 300. The curves represent first cost, and are deduced from a number of boiler plants. The forced draught system comes out at an average of 18.7 per cent. of chimney cost, while a single induced fan draught costs 26.7 per cent., and a duplex fan as much as 42.7 per cent. Assuming interest at 5 per cent., insurance at 1½, and depreciation of machinery at 4½, and of a chimney at 1½, the maintenance charges total up to 11 and 8 per cent. for mechanical and for chimney draughts, respectively. Thus, in spite of the extra charges, the cost upon the smaller outlay is less than upon the chimney, and this leaves out of account the saving of room that can usually be effected. There are no considerations of capital account or maintenance to favour the chimney.

In Fig. 1 is shown a compact chimney-draught arrangement with economiser and by-pass flues, while in Fig. 2 is shown the same arrangement with a pair of independently-driven fans, the two fans having their own engine and discharging into a steel-plate stack. In this plant for 2400 H. P. the first cost is about £16,000, of which the chimney, with dampers, accounts for fully £2200. The fans cost under £1000, complete, the net capital saving amounting to nearly £1300.

To sum up, the system of artificial draught is one that, no matter how approached, presents a favourable appearance to the experienced engineer. It is cheap to install, and cheap to run, the power to work the fan being but a small part of the economy to be gained by its use. Not merely is the first cost small, but there is a further capital economy in the reduction of boilers or their substitution by feed water heaters. And upon all there is the added convenience given by the facility of extending the plant, the freedom from the paralysing influence of the insufficient chimney, and the entire freedom from meteorological influence. A fan and electric motor make a simple combination, not liable to breakdown, and are to be recommended where possible. Electric driving is the more satisfactory when current is available from an accumulator.

Indeed, on tramway work it is necessary to take special care that the fan motor should be driven from the generator side,—not from the line side of the circuit breaker,—in order that the fan may run when current is shut off the line. In a temporary installation of fan draught, arranged by the writer and driven off the trolley wire from a station several miles distant, it was a little disconcerting to find smoke pouring out of the furnace doors when the circuit breaker acted at the distant station.

Finally, it should be stated that fans ought to be of plain and simple construction. They should be made of stout plate, and should have bearings round which a supply of water can be maintained to keep down the rise of temperature due to the heat conducted along the fan spindle. For large fans it is, of course, easy to arrange a water-cooled hollow spindle. Fan spindles must be stiff and carried in long bearings, and fans must be balanced so as to set up no vibration at their maximum velocity.

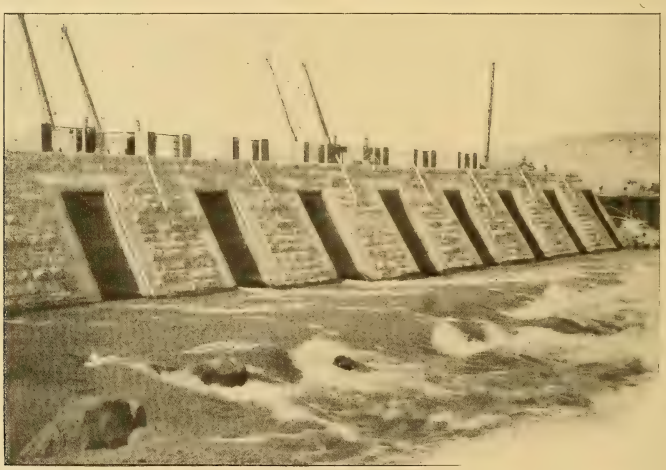
THE NILE DAM AT ASSOUAN

SOME DETAILS OF THE SLUICES

By A. J. Liversedge, A. M. Inst. C. E.

THE account of the inception and progress of the great dam now being constructed across the Nile at Assouan, which appeared in the August number of this magazine, may be appropriately supplemented by a more detailed description of the gates or sluices by which the waters of the river will be controlled and regulated when this important undertaking is completed.

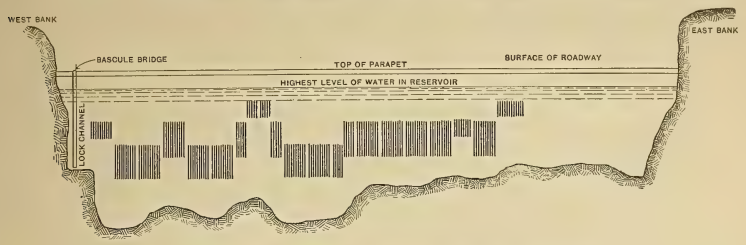
A brief note of the general scheme, by way of preface, may be here repeated, and is, indeed, necessary to a proper realisation of the immense scale upon which the works have been designed, and of the important part which the sluices are to play in them. The purpose of the dam is to convert a stretch of the River Nile above Assouan into a great reservoir where a certain portion of the flood waters will be stored for use, during the months of low Nile, for purposes of irrigation, more particularly in Middle and Lower Egypt. The dam itself is about a mile and a quarter long, extending in a straight line across the river and joining the rocky banks which there form the valley of the Nile. The width of the dam at the top is 23 feet and at the bottom about 80 feet, varying somewhat according to the depth. The maximum height of the top above datum is 347 feet 9 inches, and the maximum depth of water at the dam will be 91 feet 9 inches. The



SOME OF THE LOW-LEVEL CULVERTS, SHOWING THE SLUICE FRAMES PROJECTING ABOVE THE MASONRY

height by which the level of the water at the site will be raised is about 46 feet.

The reservoir thus created will extend for over 140 miles above the dam, and will represent a storage capacity of 1,165,000,000 cubic metres, or about 308,084,250,000 gallons. The dam is



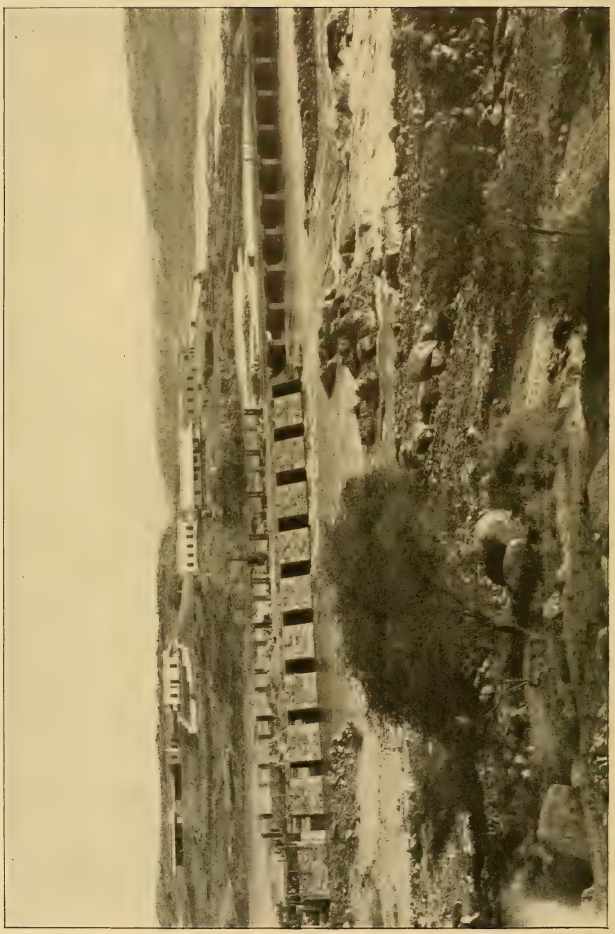
CROSS SECTION OF THE NILE, SHOWING DAM AND OPENINGS

pierced by 180 openings, which are all to be fitted with sluices. The total area of opening provided by these is 24,111 square feet, and the maximum discharge of flood water will be 494,400 cubic feet per second. At one side of the reservoir a series of locks for navigation purposes are being constructed.

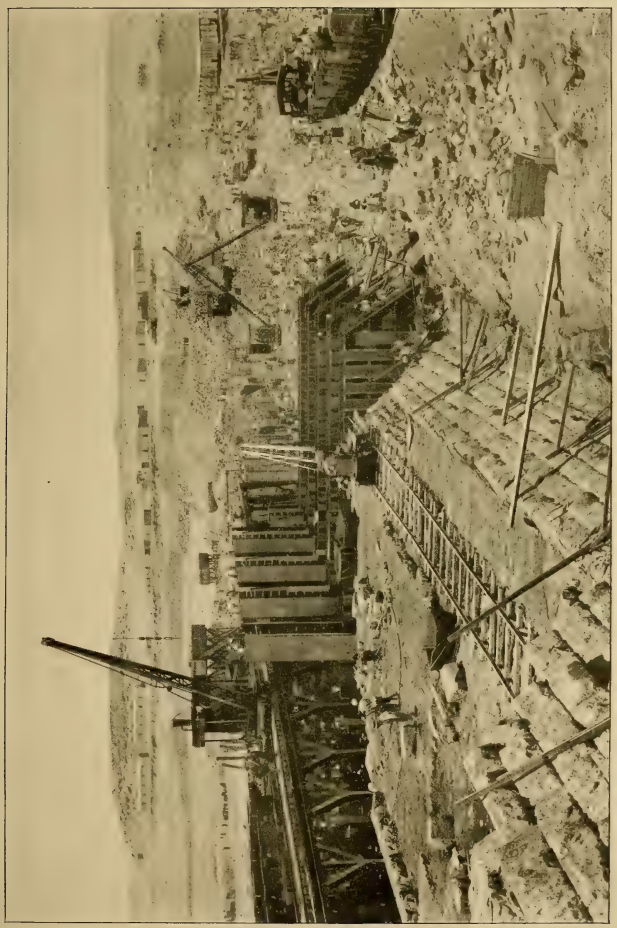
Such, in brief, is the great barrier by which the surplus waters of the Nile, in certain portions of each year, will be impounded. All the foundations have been satisfactorily laid, the superstructure is well advanced, and the immense wall can now be seen stretching in an unbroken line for a mile and a quarter across the valley. The originators and designers of the great work were required to solve two distinct sets of problems,—those connected with the construction of the dam itself, and those relating to the control and regulation of the immense volume of water which will have to pass through the culverts of the dam. The character of the former will be apparent; the latter presented special difficulties, to the solution of which much time and careful investigation were given, in the course of which the principal works of water regulation in France, Germany, and Italy were visited and examined.

A peculiar difficulty consisted in the composition of the water of the river at certain seasons. As is well known, the Nile brings down with it, in July, when the flood begins, immense quantities of solid matter, organic and mineral, which, when deposited, constitutes the famous Nile mud. To the agriculturalist of Egypt this mud is only less important than the water itself, as it forms a most valuable fertiliser for his land. It was, therefore, a prime requisite that the water-controlling arrangements should be such as to permit the flood waters, when bringing down this valuable material, to have a practically unobstructed flow through the dam. No arrangement in the nature of a common weir, which would merely permit the surface water to flow over the top, could be entertained, as any appreciable check to the flow of the flood would obviously result in a deposition, more or less rapid, of the sediment behind the dam, with the twofold result that the reservoir would silt up and the agriculturalist would be deprived of his fertilising mud. Consequently, some form of sluice gate which would open freely from the bottom and thus permit the waters most heavily charged with suspended matter to flow through became indispensable.

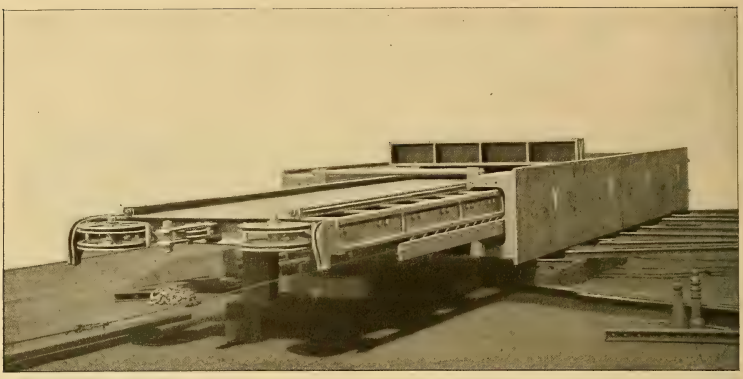
The requirements to be met were, therefore, the following:—The sluices had to provide a total area of opening of 24,111 square feet; the water to be passed would amount to 494,000 cubic feet per second; a certain number of the sluice gates would have to work under a head of 61 feet; and it was also almost an indispensable condition that the largest and most heavily loaded gate should admit of being opened and closed freely



SLUICES DURING CONSTRUCTION NEAR THE WESTERN END OF THE DAM LOOKING DOWN STREAM



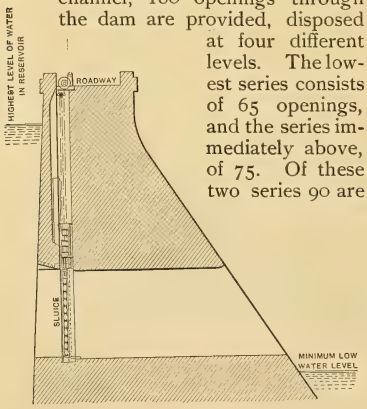
A CONSTRUCTION VIEW OF THE DAM, SHOWING THE CAST-IRON LINERS FOR THE LOW-LEVEL CULVERTS WITH SLUICE FRAMES



ONE OF THE SLUICES IN ITS FRAME

by means of hand-power apparatus. The problem was solved, after careful examination of the most likely appliances used on the Continent of Europe, by the adpotion of the form of sluice invented by the late Mr. F. G. M. Stoney, and built under his patents by Messrs. Ransomes & Rapier, Ltd., of London and Ipswich.

The scheme ultimately decided upon is shown by the diagrammatic elevation of the dam on page 141. It will be seen that, exclusive of the navigation channel, 180 openings through the dam are provided, disposed at four different levels. The lowest series consists of 65 openings, and the series immediately above, of 75. Of these two series 90 are being fitted with Stoney sluices; the remaining 50 will be provided with simple but massive iron shutters, as they will be operated only when there is a comparatively low head of water against them. Thirty of the lowest series of culverts are being lined throughout with massive iron castings. The view on page 143 shows a number of these iron liners being built in the masonry. The sluices of the whole of these lower series of culverts will be each 22 feet 11 inches high and 6 feet 7 inches wide. The weight of the heaviest sluice is fourteen tons, and the maximum head of water under which the lowest series will be operated will be 61 feet. The two upper series of culverts, forty in number, will also be fitted with Stoney sluices, but these, whilst having the same width as those of the lower series, will only be of half the height. These upper sluices will be used for regulating the water when the reservoir is full.



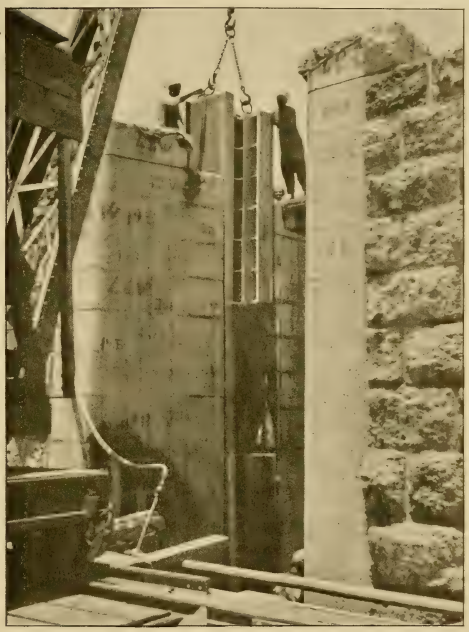
CROSS SECTION OF THE DAM SHOWING STONEY SLUICE CLOSED

The construction of the Stoney sluice is shown in the cross section of the dam given on this page. The distinguishing feature of the device, wherein it differs from other forms of sluices, consists in the interposition of a series of free anti-friction rollers between the gate and the jamb against which the gate must move. The difficulty of operating large valves or gates under considerable water pressure when the gate moves against a

rigid face or guide is well known. The difficulty is not merely in opening the gate, but even still more in closing it, and will be readily understood when the pressure against which such a sluice may have to work is kept in mind. For example, the pressure against which one of the lowest series of sluices in the Assouan dam will have to operate will exceed 300 tons, whilst the sluice must open and close in a solid stream of rapidly moving water. It is not too much to say that no other known form of gate could be operated under the given conditions. Nevertheless the freedom of movement secured by the anti-friction rollers of the Stoney system is such that any one of these sluices, although unbalanced, can be opened by two men by the aid of a simple crab winch on the top of the dam, whilst gravity alone will close them, when released, with absolute certainty.

It will at once occur to the reader that the interposition of the rollers between the face of the sluice gate and the face of the jamb must permit excessive leakage. This would obviously be the case but for another extremely simple device of Mr. Stoney's. The anti-friction rollers are, of course, on the down-stream side of the gate. On the up-stream side and in the vertical angle formed by the face of the gate and the side of the jamb or guide, a round iron bar is hung freely. The pressure of the water forcing this bar or "stanching rod" into the angle secures a tight joint. Both the stanching rod and the anti-friction rollers hang quite freely and move with the gate. The illustration on the opposite page shows one of these patent sluices, as made for Assouan, fitted in its framing. The gate is seen resting upon its anti-friction rollers. The view is from a photograph taken in the yard of the builders' works at Ipswich. It is not necessary to explain that, although this view shows the sluice laid flat on the ground, the apparatus is built vertically in the dam. The view on this page shows a set of cast-iron frames for a sluice being fitted into the masonry. The weight of this framing is thirty-one tons.

Such is the apparatus which, built as indicated in the culverts of the Assouan dam, will constitute the gates of the Nile. The sluices will be operated in a regular routine, corresponding with the variations of the river and the requirements of the districts to be irrigated. It should be explained that, under this scheme, irrigation will not be effected direct from the Assouan reservoir. Another dam is being built at Assiout, about 330 miles lower down the river. The stretch of river between the two



FITTING ONE OF THE CAST-IRON FRAMES INTO PLACE

A VIEW OF THE STORAGE YARD FOR MATERIAL AT ASSOUAN

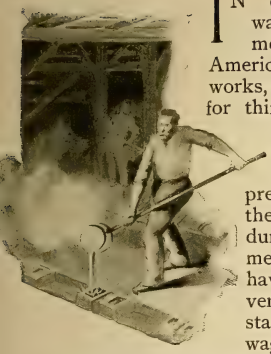
dams will constitute a service reservoir from which water will be diverted into the Ibrahimieh irrigation canal and thence to the land under cultivation.

During the time of high Nile, commencing in July, and whilst the waters of the river are heavily charged with suspended solid matter, the sluices will be freely opened. As the flood subsides, the water becomes clearer, and in the month of December the process of impounding the surplus water of the river will begin and be carried on by the gradual closing of the sluices until the reservoir is full. The surplus thus stored will be released, as required during the months of April, May, and June, and distributed by means of the canals for use in Middle and Lower Egypt.

Nearly 11,000 tons of ironwork will be required for the completion of the sluices and for the locks of the navigation channel at Assouan. Of this quantity more than half has already been shipped.

WAGES AND LABOUR IN THE AMERICAN IRON AND STEEL TRADES

By William Garrett



IN considering the wages paid to the men employed in American iron and steel works, — looking back for thirty-five years,— it is remarkable to note that the wages at the present time and the wages per day during the period mentioned above have varied but very little. For instance, while the wages paid for the common labouring men during the time of the Civil War were $1.75 per day, and the wages paid for the same class of labour during the panics of 1873 and 1894 went as low as $1 per day, yet when we come to average up the wages for common labour for a period of, say, thirty-five years, we will find that the figure comes to an average of what is paid at the present time, viz., $1.50 per day.

One of the most remarkable instances in trade, to belie the saying that corporations have no souls, is the fact that common labour, without the aid of any labour organisation or union to support them, is receiving the wages that are paid to-day. When we find what is paid elsewhere for common labour, say, for instance, in Great Britain, where the amount ranges from three shillings to four shillings per day,—the latter being equal to about ninety-five cents,—and when we go to the Continent and find that fifty cents per day and even less are the wages received there for this class of labour, and then think of the thousands upon thousands of ignorant emigrants that come into the United States every year who are fit only for that class of labour, does it not seem remarkable that manufacturers did not reduce the daily wages of the common labourer in America far below what was actually paid? It affords a striking illustration of good wages for a certain class of work being obtained and maintained without the aid of organisation on the part of labour.

In figuring the cost of manufacturing iron and steel, the item of the common labour to-day does not differ much from that of thirty years ago. It is true that by the use of steam shovels, and steam ploughs, and electric cranes, less men are employed for excavating and digging. In the case of skilled labour, however, we find that the most remarkable change has taken place in that thirty-year period, the daily wages received by skilled labour to-day, excepting in some rare cases, being equal to the highest paid at any time; but the amount of material in tonnage handled to pay this wage in many cases is over ten times as great as it used to be.

In the great strike which took place at the Homestead works of the Carnegie Steel Company several years ago, the men who organised it were not the common labouring men who then received about $1.35 per day, not the machinists and engineers who received from $2.25 to $2.75 per day, but the skilled labour around the rolling mills and melting furnaces,— men who received, after the strike was settled, amounts ranging from $2.50 to $12 per day.

It was customary with the Carnegie

Steel Company to spend a certain amount of money every year for certain improvements whereby the product was increased in a given time without any extra effort on the part of the men employed around the mills, and then the increase in the product was so rapid and so regular every year that, no matter what adjustment was made at the beginning of the year, at the end of that same year the men received on an average per day the same that they received during the year preceding.

It must be said in behalf of the Amalgamated Association of Iron and Steel Workers of the United States that it was distinctly understood between them and their employers that any improved machinery put in by an employer was to be honestly handled by the men, and they were to submit to the removal of the men supplanted by this machine without any complaint. What a vast difference is this to that of the conduct of organised labour in Great Britain, for example, which fights, tooth and nail, every improvement put in by the manufacturer to reduce the cost of production; in fact, insisting, no matter how well this machine is doing its work, upon keeping the same number of men at work that were employed before the machine was put in operation.

A striking instance is that of the Wellman-Seaver open-hearth charging machine, which is almost universally used in the United States, and which does away with a great number of men. But the few machines of this kind in use in Great Britain do not save any labour there, as the union men demand the full equipment of men employed under the old system. This is one of the many reasons why Great Britain has lost ground in the manufacture of iron and steel. At one time in the United States a roller in a rail mill, rolling iron or steel rails, received about fifteen cents per ton, turning out from 75 to 100 tons per turn. To-day, on some of the modern steel rail mills less than one cent per ton is paid for doing the same work, and yet by the end of the year the roller in the rail mill to-day can make as much money as he did when he received the above higher prices under the old method of working, and that, too, with less physical labour.

At one time forty-five cents per ton were paid for heating iron for making iron rails. To-day, through the use of the improved methods, very little more than half a cent per ton is paid for doing the same work,—making steel rails,—and yet the wages received per month or per year are as good, and better, to-day than they were at that earlier time.

One of the most remarkable results in this direction recorded in the history of iron and steel is the price paid for rolling wire rods. At one time, about twenty years ago, a man having charge of a rod mill received $2.12 per ton of rods made, out of which he paid no help whatever. At that time twelve to fifteen tons were considered a good day's work. To-day it has become almost common practice to make 200 tons of wire rods in a single turn; and upon the basis on which rod rollers are paid to-day, they would not receive much more than twelve cents per ton. This, however, enables the roller of to-day to make as much money as the roller did twenty years ago, producing only twelve tons per turn.

About twenty years ago eighty cents per ton were paid for heating billets to make wire rods; to-day five cents per ton are commonly paid, and the daily wage is higher than it was when eighty cents per ton were paid.

If some of the rollers now employed at the Homestead Works of the Carnegie Steel Company rolling structural steel were paid the same wages per ton that were paid twenty years ago they would be receiving from $200 to $250 per turn on a single day's work. On the same basis, if rod rollers to-day were to receive the same per ton that they received twenty years ago, viz., $2.12, then for a turn's work of 200 tons they would receive $424 per day, or single turn. Yet this was the bone of contention that led to the great Homestead strike which outraged the feelings of

all organised labour societies in the world.

It is evident that Mr. Carnegie and his assistants thought it right and proper that they should have some return for the money that they expended in the way of adopting automatic machinery, and not only save the labour of a great number of men, but increase the product, and the result of the whole matter, when summed up, is this,—that the wages paid to the men around those works to-day are higher, on an average, than those paid by any other corporation in the world; and with all that the American consumer of iron and steel can get the products at a lower cost than the consumer of any other nation.

This is the result of the march of progress of an enlightened nation. There is only one relic left in the United States in the manufacture of steel that belongs to the Dark Ages, and that was brought over by some European prejudiced workman in connection with the manufacture of tin plate. In this the product is restricted to a certain amount, no matter what the actual capacity of the hot tin plate mill may be; but it will be only a matter of time when this will be rectified and the tin plate workers will fall in line with the other workers of steel by trying to produce not a minimum quantity in a given time, but a maximum.

It is remarkable to note in connection with the matter of wages paid in the rolling mills that very little, if any, change has taken place in the wages of those who are employed at the present time as puddlers, $5 per ton being about the maximum and $3 per ton the minimum during thirty years, and to-day $4.50 is about the rate. The puddling process is conducted to-day throughout the entire civilised world as it was conducted over forty years ago. The same number of heats are taken out in a given time and about the same weight is produced.

There is no question that the possibility of the Bessemer process and the open-hearth steel process sooner or later making the old method of puddling iron unnecessary has had a great deal to do with the lack of energy or exerted ability to improve the method of puddling iron, and there is only one conclusion that can be reached in discussing this question, that had there never been any better method of manufacturing iron and steel than the old method of puddling or the crucible steel method, the standard of civilisation would not be as it is to-day. The same thing can be said in reference to the rolling of puddled bars in the shape of puddled iron into finished bars, for the majority of the mills to-day that are used for rolling iron bars are of the same type, and almost identically the same as those used by our grandfathers.

It is only by the introduction of the Bessemer process and the open-hearth steel process that a new pathway was opened up whereby it was possible to produce such large quantities of material in a given time and at such a low cost. It may be said that as much iron is used to-day in the United States as there was thirty years ago. That may be true, but thirty years ago the population of the country was less than half of what it is at the present time, and owing to the cheapness of Bessemer and open-hearth steel more iron and steel per capita are used to-day than there ever were. It is worth noting here that the higher the grade of civilisation, the more iron and steel are used per capita.

It may be a matter of interest to know which has the supremacy,—iron or steel. If we take the United States, we find that in times of depression Bessemer steel is sold at a less cost than iron, including bars, rods, sheets, plates, skelp, etc. That steel suits all the requirements of iron, except for rare cases, is evident, seeing that within the last five years, in spite of all the prejudices against using steel, the Jones & Laughlins Company, of Pittsburgh, and the Milwaukee plant of the Federal Steel Company, the two largest manufacturers of iron bars up to that time, commenced rolling nothing but steel, and to-day the quantity of steel bars sold by them is double the quantity of iron bars, iron skelp, iron sheets, and iron tin plates formerly turned out by them. Iron is a thing of the past, and every

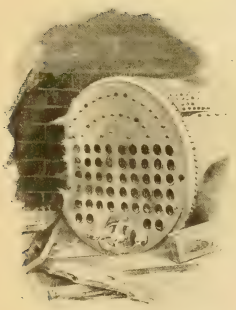
panic or depression in the iron and steel trade helps to push it further into the background.

Referring once more to the question of wages and organised labour, it may be asked pertinently whether organised labour sustains wages regardless of supply and demand. Was there ever an advance in wages when the market value and demand was low? The writer does not remember a single instance. Was there ever a time when prices advanced and the demand was great that wages were not advanced, with or without the aid of organised labour? The writer questions it. True, organised labour might defer in one case and hasten in the other, but supply and demand in the end controlled the whole matter. Iron and steel workers, including rolling mill men, are the autocrats among working men; their wages have been always better than those paid to others, chiefly because of the character of the work which demands both brain and muscle, demands effort and judgment.

To the earnest student of the matter of wages one thing stands out prominent from past history,—that the high wages shall become lower and the low wages higher, thus bearing out that passage of Scripture which saith,—"The valleys shall be exalted and the hills shall be laid low."

UNFINISHED INVENTIONS

By C. W. Scribner



GLANCING over published reports of patented inventions shows that the ideas set forth are, in many cases, wholly impracticable. As an extreme example, take the proposition to run tramcars by a continuous series of gear wheels, turning on horizontal axles fixed in a conduit between the rails and meshing together so that each is driven by the one preceding, the alternate gears, rotating in one direction, being larger than the others, and engaging with a rack suspended below the car, thus carrying it along. While this proposition, which appeared many years ago, may go further than most in the direction of the preposterous, very many patented devices have little more to recommend them. And yet, though commonly enough the failure of a patented article results from the fact that it is impracticable or that there is no real demand for it, there are numerous instances where inventions which are really needed and which have true merit fail of success from other causes.

Often, in the experimental stages of a new invention, well-known principles of mechanics or of machine construction are ignored, and the fact that failure so often results from these causes is a lesson that is seldom learned. The following incident, which came under the observation of the writer, illustrates such a case. Several people who wanted to experiment with a new sugar-making process rented power and space for their premises from a small shop, and got sufficiently well started with their test to see promise of success for their process. But difficulties arose with their cane-crushing machinery. It broke down again and again, causing much delay and the loss of their cane supply, and at length the stockholders grew so much discouraged that the whole proj-

ect was abandoned as a failure. Here the machinery was correct in principle, but poorly built in certain parts where good construction was essential. And not only the promoters, but the inventor, too, failed to perceive that defects of construction were chiefly responsible for what occurred. If half the money lost by delay and expended in repairing preventable breakdowns had been used at the outset in providing mechanical knowledge and insuring good construction, the machinery could have been made to do its work and the process would have been saved from failure.

"It is only an experimental machine and expense must be limited," may serve very well in getting up non-essential parts, but more often in such experimental work it is fundamental to remember that "what is worth doing at all is worth doing well," even at an expense which may seem, at the time, disproportionate. The ordinary mechanic, called in to repair such a breakdown, may exclaim,—"They ought to have known it would not work."

But if it is astonishing that such failure was not foreseen, it is still more astonishing that so often, after the obvious has happened, the principle involved is blamed for the failure by intelligent people whose experience should have suggested that they suspend judgment if unable to locate the trouble. Too commonly the end desired will be pronounced impossible of attainment, and if perchance some different contrivance, elsewhere, is successful in partially achieving the looked-for result, more because of perfection of workmanship than owing to entire fitness of the theoretic principle, the inferiority of the methods attempted in the first instance is taken as demonstrated, whereas the reverse may be true.

But many an undertaking in which mechanical ability is not lacking comes to nothing for want of patience, caution, and proper business management. The development of a new invention very often involves a large expenditure of time and money, and even in those cases where intelligent foresight and mechanical skill have done their best to insure success, unforeseen difficulties are almost certain to arise. The experimental machine must be humoured in every way, and should not at the outset be called upon to do even its regular work if the case admits of a run without load.

It may not be amiss here to note the following occurrence which took place in the early days of electric railway work. Several men, wishing to develop some real estate not far from a populous city, were planning to connect it with the town by an electric line. They were induced to adopt a system in which the cars were suspended beneath a set of overhead rails, as the style of traction best suited to a right of way through a rolling country and off the line of any road. The system had never been put into service, and a trial section of the road was put up on trusses and columns, and an ordinary car was fitted with overhead electric trucks and everything made ready for the demonstration.

While there was good reason to expect that after minor troubles had been overcome the system could be successfully operated, the manager of the venture arranged to have this experimental car start on its first trip at the foot of an exceedingly steep grade, and, furthermore, invited the public to witness the initial trial. Slight difficulties, which might have been discovered and cured in a start on a level track, prevented the car from making the run up the grade, and as the failure occurred in the presence of a large number of people, its effect on the contemplated real estate venture could readily be imagined. A few further trials were conducted in the same way, and failed to give satisfaction. Those in charge of the road would not consent to a trial under better conditions, since to change the arrangements would involve considerable expense. The moneyed interest lost faith in the scheme. "Too much has already been spent," they said, "and if the car won't climb the grade empty, what will it do with a load?" The conclusion was, therefore, reached that the road could not be made to

work, and the undertaking was abandoned.

That occurrences of this sort are frequent enough is a fact well known to engineers. But the common verdict is that a failure is a failure, and that causes can well be ignored. Since money is often needed for the proper development of an invention which mechanical knowledge and genius have made possible, partial failure at the outset, which may react unfavourably upon capital, must be carefully guarded against, for the cause of such failure is most apt to be ascribed to inherent worthlessness, rather than to accidental conditions which could readily be remedied. The result thus is likely to be disastrous.

There is still another and a most important consideration which ought to be presented. However carefully any machine or other invention may have been planned, minor, and possibly serious, defects, both in design and construction, are liable to develop with time. In spite of the fact that it may seem, at the beginning, to be an entire success, certain unusual conditions often appear later on which interrupt its usefulness and render its service unsatisfactory.

Again, continued use may indicate possible improvements which would either simplify its construction or increase its efficiency by making it useful in some new and unintended capacity, or by making it easier to handle. It is, therefore, to be regretted that those concerned in manufacturing seldom have any experience in the continued use of their own products. In certain cases where this would be out of the question it would be very helpful if intelligent criticism or suggestion were invited from those who have the actual handling of the article produced. Let us suppose, as an exterme case, an automatic machine! Assume that no mechanical knowledge nor high order of intelligence is demanded of the operator! Still, the fact that he works with it day after day, until he seems almost to have become a part of it, will often result in his observing slight defects or chances for improvement, a knowledge of which might prove of great value to the maker of the machine. Still more would this be true for machines requiring intelligent handling, or for new inventions involving a radical departure from lines of previous experience.

There comes to mind the case of a gas-engine,—a design of unquestioned merit. Entirely correct in theory, it was brought, by costly experiment, to a condition where the trial results were eminently satisfactory, so that the reports of its performances earned for it a wide reputation, and great things were expected of it. If at this point a simple form of the machine had been constructed from which, even at some slight expense of thermal efficiency, all possible complications of mechanism and every element of its action involving possible uncertainty had been eliminated,—if this engine, thus simplified, with details properly designed, had been built of the best materials and tried for many weeks continuously by its builders at some regular service, it might have substantiated the claims made for it, won the confidence of capital, and earned a considerable financial return when first put upon the market.

But it failed to accomplish all this through neglect of the necessary conditions. Its service, excellent at the beginning, became unreliable. In spite of defects that were obvious, its economy of operation would have made it invaluable but for repeated breakages from causes that were obscure, and due to unusual conditions of working which occurred only at intervals. These troubles might, perhaps, have been anticipated from a careful study of the experiences of others; but at all events, if the builders had had their machine at work under their daily observation for a long period they could have put it on the market in a reliable form. As it was, no advantage was taken even of opportunities afforded for studying the action of their machine in the service of those who had purchased it. And when some of the users, after serious inconvenience, had discovered the cause of the breakdowns and a method of getting round the difficulty, not only had

they to make the necessary changes at their own expense, but their explanation of the trouble and suggestions for its cure were alike ignored by the builders. In this case the users of the engine felt well repaid for their pains and expense, since from that time forward it continued to serve them with remarkable economy and called for no further attention. On the other hand, the attitude of the builders remained unchanged, and they allowed the place in the market which they might have filled to be occupied by various competitors.

Investigation would reveal numberless instances where much-needed inventions have never come into use, or else, after a short trial by the public, have lost ground and disappeared, when their success might have been assured had the originators made it their business to gain that acquaintance with the defects of their productions which can come only from actual service.

Attention may be called also to certain productions which may be classed together as being used everywhere, but always in a condition needlessly imperfect. The point of view is now changed. It is here the consumer who chiefly suffers, and either through ignorance or thoughtlessness he enters no complaint. Those who supply the demand can feel that, at least from a money standpoint, they are successful, if they accomplish nothing else. Generally, for contrivances not absolutely needed, if the cost is excessive, or if they soon cease to give satisfaction, we simply get along without them till some competing device has overcome the objections. But there are certain articles which, though poorly adapted to their purpose, or, at best, capable of great improvement, are practically indispensable, and must always find a market. Year after year their manufacture continues, with no apparent attempt to cure defects which are obvious enough, and which, in a different class of products, would not be tolerated. A striking example is to be found in the common house-pump, and particularly in the hand-force-pump. Especially in the working joints and bearings faulty design, poor workmanship, and absence of provision to insure lubrication unite to bring about a more rapid wear of the parts than can be found in any other machines in common use. The pumps are considered quite satisfactory if they do their work when new, and the idea of designing them to stand the unusually hard service they are sure to get, or of proportioning their joints to wear well, is apparently furthest from the thought of the manufacturer. If chance circumstances should require him occasionally to lift a thousand gallons of water with a force pump of his own make which had seen a year or two years of ordinary service, he would, doubtless, view these matters in a new and different light.

But this is merely an illustration of what is true of the majority of mechanical contrivances which are widely used by those who, for the most part, have no knowledge of mechanics. Such inventions do accomplish in a half-way measure what is required of them, and those who use them never imagine that something could be made which would more perfectly meet the requirements and yet be far more reliable and easily handled. In exceptional instances this has already been done. What is there in more common use than the modern spring roller for window shades! But if we pass over the cheap imitations of the original invention, who is likely to wish for a substitute or to try to improve its action? But here, again, the exception proves the rule, and a careful study of this part of the subject would reveal a wide field for useful invention. And promise of financial success would be certain, provided the inventor, before he let go of his work, would persistently and personally use what he himself makes until continuous usage had brought to light every defect, and long-standing acquaintance had suggested every possible improvement.

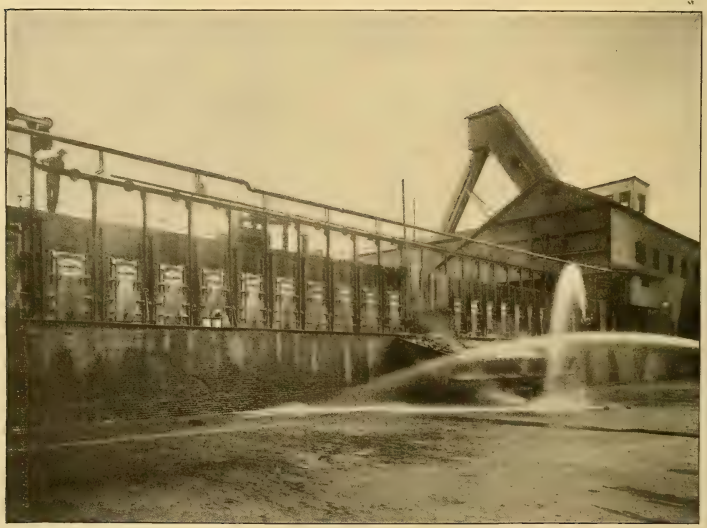
BY-PRODUCT COKE OVENS

THEIR WIDENING USE IN THE UNITED STATES

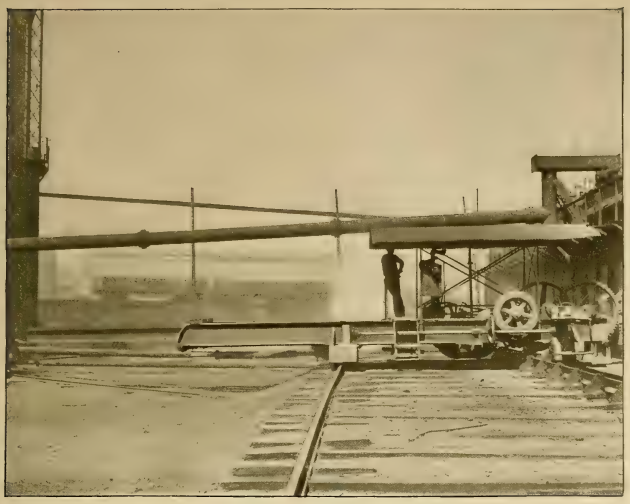
By Frank H. Crockard

THAT the early coke makers endeavoured to effect a saving of by-products is indicated by the fact that crude attempts having that end in view were made near Saarbrücken in 1766, and from that time to the present numerous more or less successful efforts have been recorded. In the United States, with extensive areas of excellent coking coals, coke makers have naturally been somewhat slower in adopting the retort ovens than in the Old World, where, with few exceptions, the coals are of such a lean nature as to require the use of retort ovens for the production of a suitable metallurgical fuel. Indeed, some European coals are so poorly adapted for coke making that it is necessary to stamp or compress them before charging into the ovens.

The use of retort ovens in the United States to-day is dictated by economic conditions and advanced engineering practice; later, when it becomes necessary to meet the demands of an ever enlarging coke market, requiring the use of secondary qualities of coal, by-product ovens will be adopted as a matter of necessity. Their ability to coke coals which would be worthless in the beehive type of ovens is due to the more rapid application of heat, which fixes the coke-making portions of the coal before they have time to escape, and



THE DISCHARGE SIDE OF A BANK OF SEMET-SOLVAY OVENS. QUENCHING THE COKE



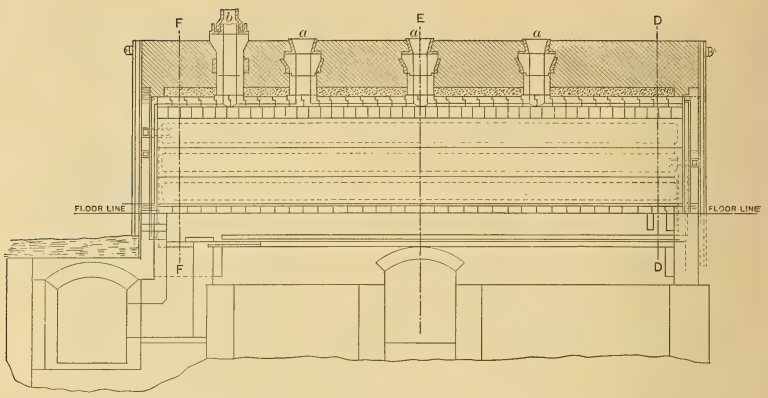
THE PUSHER END OF THE OVENS

to the narrow form of the retort, which prevents expansion of the coal in the direction of the flow of the gases and thus causes the formation of a dense cellular structure in the coke. The gases driven off in the process of coking pass from the sides to the centre, then to the top of the coal charge, forming a cleavage plane half way between the two walls, along which the coke separates when pushed from the oven. The pieces thus formed are never larger than a little less than half the width of the oven, thus differing from the long needles or fingers of the coke produced in the bee-hive oven.

A number of retort oven designs are at the present time submitted for consideration, but of these only the most prominent and distinctly defined types will be considered. The one, of which the Semet-Solvay may be taken as the chief exponent, has superimposed horizontal flues, and continuous heat recuperation; the other, of which the Otto-Hoffmann may be taken as the representative, has vertical flues and regenerators.

In the Semet-Solvay type the oven chamber is about 30 feet long, 5 feet 6 inches high, and from 15 to 20 inches wide, depending upon the particular coal to be coked. The side walls of the oven chamber are built with flued and jointed Belgium tiles, laid up in silica cement, and driven home, forming air and gas-tight joints. The tiles are not over 2½ inches thick, thus permitting a rapid transmission of the heat from the combustion of burning gases within, which, supplemented by the heat stored in the dividing walls between the flued linings, and also the heavy arch and covering over each oven, insures a sufficiency of heat at the upper portion of the charge of coal and maintains a uniform oven temperature. In ovens of this type the side wall flues are usually three in number. The latest type of the Semet-Solvay oven is four flues high. The flues are placed horizontally one above the other, extending the entire length of the oven, and are connected with one another at the ends, thus forming a continuous flue of the burning gases.

The practice regarding the condition of the coal before it is introduced into

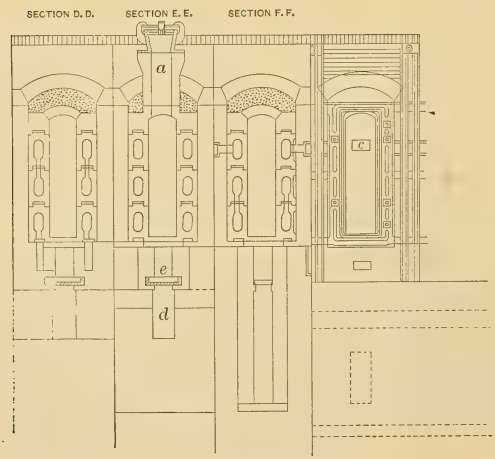


LONGITUDINAL SECTION OF A SEMET-SOLVAY COKE OVEN

the coking chamber is not uniform. In some cases the preferable method of crushing the coal is followed, and in others this preliminary treatment is disregarded. The coal storage bins are generally located at the end of a battery not exceeding twenty-five or thirty ovens.

Where a group of fifty or more are operated, it is usual to locate the coal bin in the centre of the plant, thus minimising the larry travel, and also providing a convenient place for the boilers between the two batteries and immediately under the coal bins.

Starting with the coal bin, we find three larries, each holding one and one-half to two tons, receiving their charge of coal from overhead spouts; from this point they descend upon a gentle grade and are stopped over the oven to be charged. The coal is discharged from a centrally disposed sliding bottom into one of the charging ports *a*, shown in the diagrams on this page. The coal charge, amounting to from four and one-half to six tons, is now leveled with leveling hooks introduced from both ends through small openings *c* provided in each door. The charging and leveling doors are then closed and made air-tight by careful luting.



CROSS SECTIONS OF A SEMET-SOLVAY OVEN

The oven, hot from the previous charge, promptly begins its work of distillation. The gases evolved are constantly changing in composition, depending on the time and temperature, all,

however, escaping from the oven to the hydraulic main through the up-take, or riser, *b*. The hydraulic main is a large iron flue extending the entire length of the block; the lower portion is partially filled with water through which the gas is caused to bubble by means of exhausters. Here the first portions of tar and ammonia are condensed. The gas next passes through the condensers, which are simply huge vertical cylinders filled with tubes, through which water is allowed to circulate. The gas circulating around the tubes suffers another reduction of temperature, causing additional condensation of the tar and ammonia.

Leaving the condensers, the gas passes through the exhausters, and from there is discharged into the gas washers, where the remaining portions of ammonia are removed. The washed gas is now divided into two portions, one of which may be conducted to a gas holder from which it is sent to various points of consumption, while the other is returned to the ovens and introduced into the side flues, where it is burned by mixing with air which has been heated by passing through arches forming the foundation of the ovens. Having performed its work in the flues, the gas is conducted to the boilers, finally escaping into the chimney at a very low temperature, showing how efficient the heat utilisation has been in this type of ovens.

After the coal has been properly coked, the time necessary varying from twenty-two to twenty-four hours, the oven is discharged. This is accomplished mechanically by opening the doors at both ends, and allowing the steam ram (shown on page 559) to push the block of coke through the discharge end, from which point it falls into the quenching car. The time consumed in discharging an oven does not exceed two minutes. After discharging, the oven is promptly closed and charged as before.

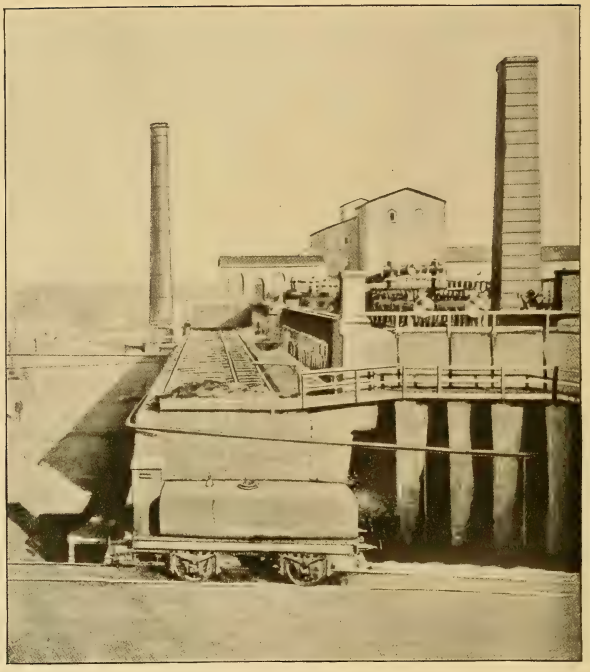
The retort coke being quenched outside of the oven, it is necessary to use considerable care in the operation; otherwise, the moisture is apt to run higher than in bee-hive coke. Owing to this external quenching, by-product coke, as found on the market, does not possess the silvery lustre so characteristic of bee-hive coke; it is, however, plainly noticeable while the coke is being discharged from the oven.

So long as the coke is charged into

A QUENCHING CAR ON ITS WAY FROM THE OVENS TO THE COKE BINS

the furnace by volume, the presence of moisture does not seem to have any injurious effect; but it doubtless decreases the efficiency of the furnace gases slightly when burned under the boilers or in the stoves, since the vapour of water has to be raised to the temperature of the burning gases.

The Otto-Hoffmann oven is shown in the diagrams on page 159. The method of charging and discharging is about the same as in the first type, but the flue arrangement is radically different. The heating system of the Otto-Hoffmann oven is based upon the Siemens regenerative principle. The gas from the main *g* is introduced into one side of



VIEW OF A BATTERY OF OTTO-HOFFMANN OVENS

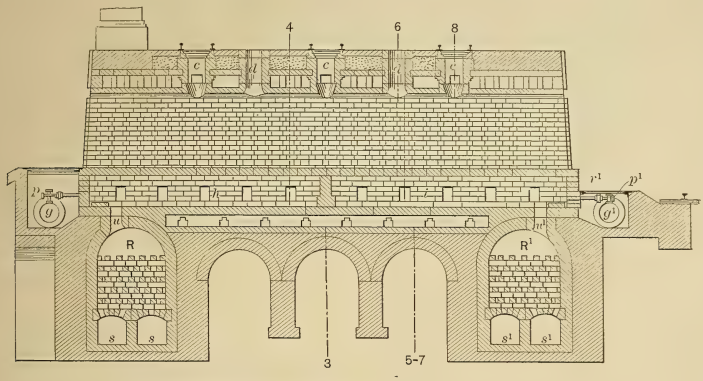
the oven through the tuyere pipe p. Air is forced, by means of a fan, through chambers s in the regenerator R, passing over the previously heated checker work, and through the porthole u into the bottom flue of each oven on to the adjoining chambers, where combustion takes place. The products of combustion expand within the bottom chambers until checked by a partition wall, thus forcing the gas through sixteen vertical flues contained in the side walls; uniting again in the upper chambers, the flame travels over the other side of the oven, descending through corresponding flues to the other gas chamber, then to the bottom flue and through the porthole u^1 into the regenerator R^1, where a portion of the remaining heat is taken up by the checker work, and finally from there the gases pass on to the boilers, where the last available heat is given off. The course of the gases is reversed every hour.

As to a comparison of the output of the bee-hive and by-product ovens, the results at the Ensley, Alabama, plant of the Semet-Solvay Company indicate that 120 retort ovens will equal in production about 300 bee-hives making forty-eight and seventy-two-hour charges, and about 340 bee-hives making seventy-two and ninety-six-hour coke.

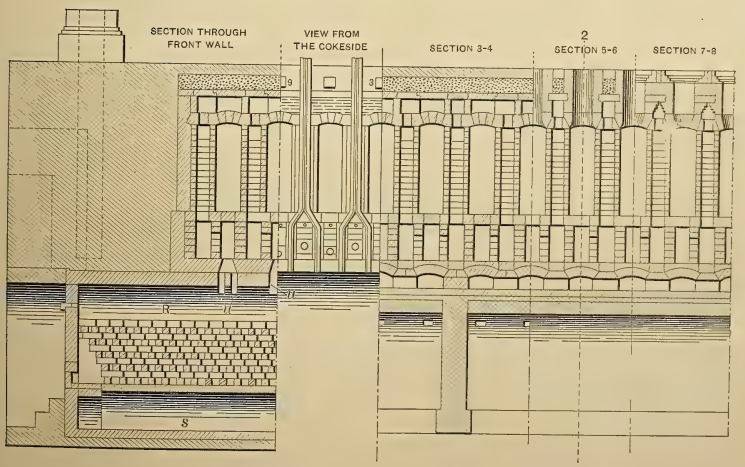
We now come to the products of the retort oven. In the case of the retort coke we find the yield very much increased. In the bee-hive, where the coal is coked in the presence of air, the yield is about 65 to 66 per cent., while with the retort oven the same coal would probably yield 74 or 75 per cent.

The theoretical yield of the coke is exceeded, as the exclusion of air prevents any combustion of the fixed carbon of the coal, and because of the more complete deposition of the carbon from the escaping gases produced by the high temperature of the oven when charged. This increased yield reduces proportionately the percentage of impurities, and, therefore, affords a purer coke from the same coal. At a very careful comparative test made at one furnace, it was found that retort coke offered greater resistance to the dissolving action of the carbonic acid; the ratio of carbonic acid to carbonic oxide was found to be 1 : 2.47 with the bee-hive and 1 : 2.27 with the retort coke.

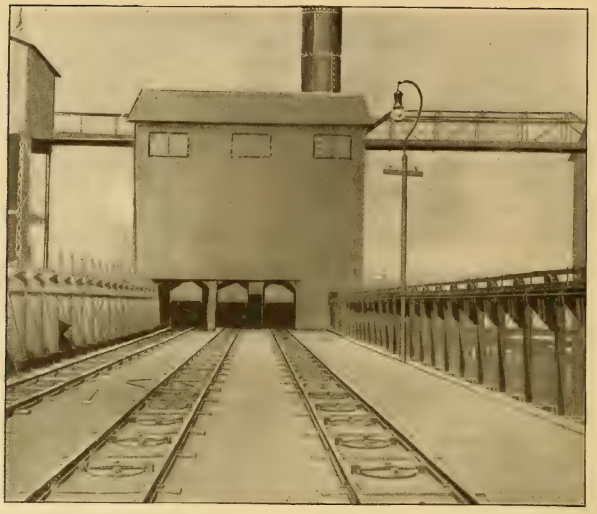
Until the year 1898 American furnace practice on 100 per cent. by-product coke was an unknown and a mysterious field. Doubt was entertained as to the



LONGITUDINAL SECTION OF AN OTTO-HOFFMAN COKE OVEN



CROSS SECTIONS OF AN OTTO-HOFFMANN COKE OVEN



SEMET-SOLVAY COKE OVENS AT THE RIVERSIDE IRON WORKS, WHEELING, WEST VIRGINIA. THE TOP OF A BATTERY

ability of the coke to carry burden; some thought it would not stand the blast; others insisted that the blast requirements would be very much increased. Predictions of decreased output for a given stack were freely made, and owing to the extreme hardness of some portions of the coke, it was feared that well-defined heat zones could not be maintained. After a period covering a two years' run on all-retort coke, it is found that all these doubts were groundless.

A Bessemer furnace, in charge of the writer, has given results in every way satisfactory, and this in the face of the fact that the total ore burden is now composed of 100 per cent. fine ore, where previously one-third of the ore burden was composed of easily reduced lump ore, giving a slightly higher yield of iron; the product for the period covered exceeds all former records, and this, with a furnace now in the sixth year of its blast.

The by-products of retort coke ovens consist essentially of ammonia liquor, gas and tar. Ammonia occurs in the liquor in two forms,—fixed and volatile. The former is ammonia in chemical combinations, as sulphate, chloride, cyanides, etc., and is recovered as free ammonia by distillation with lime.

The volatile ammonia includes the carbonates, sulphides, and possibly some free ammonia. The ammonia liquor when first drawn from the tar is quite weak, usually carrying 0.75 to 1 per cent. of ammonia. This liquor, along with an emulsion of lime, is introduced into the top of a large cast-iron cylinder, known as the ammonia concentrator. A jet of steam introduced at the bottom of the concentrator accelerates the liberation of ammonia gas.

In case it is desirable to manufacture ammonium sulphate, the ammonium hydroxide found in the concentrator is conducted into vats containing sulphuric acid. The sulphate formed is removed from the vats by means of perforated ladles, and is placed in a centrifugal dryer. Being a fertiliser of a high order, it finds a ready market. The ammonium hydroxide may also be con-

verted into aqua ammonia, or anhydrous ammonia, which is used in refrigerating apparatus.

The ammonia yield does not depend entirely upon the amount of nitrogen in the coal; in general, it seems to be the case that a larger percentage of the total nitrogen is recovered as ammonia from those coals in which the percentage of oxygen is high. It also varies with the temperature to which the coal is subjected during coking. The coals from the Pittsburgh district will yield from 13 to 19 per cent. of the total nitrogen of the coal. In a well-known plant near Pittsburgh the ammonium sulphate yield is from 1.25 to 1.45 per cent. per ton of coal charged. The yield of tar from the same coal is from 5 to 6 per cent. Tar produced from retort coke ovens is superior to that produced in gas works, since it contains less pitch.

In Europe the oils obtained by the distillation of the tar are put through the complex processes of modern chemistry, yielding valuable substances in infinite variety. In the United States this field has not yet received attention commensurate with its importance, and the greater part of the tar product is used for the cruder purposes. The gas evolved from coals of the Pittsburgh district will amount to 8000 or 10,000 cubic feet per ton of coal, the calorific value of which may be taken as about 650 B. T. U., while that of natural gas is about 1000 B. T. U. The commercial value of the gas varies with the location of the ovens. When these are at the mine, the gas has a minimum value; when in proximity to mills, the value is very much increased, owing to its intrinsic value as a fuel and the ease with which it may be employed. When within piping distance of a city, the gas reaches its maximum value. If deficient in illuminating power, it may be enriched by one of the well-known methods, or it may be used without enriching, in incandescent burners.

By-product plants in America have uniformly passed through their infantile vicissitudes with such satisfactory results that it is fair to conclude that their general adoption depends simply on a fuller appreciation of their intrinsic merits. Bee-hive plants may continue and increase for the time being, but the gradual replacement of a method so antiquated and wasteful seems inevitable.

ELECTRIC POWER SUPPLY IN GREAT BRITAIN

A LOOK INTO THE FUTURE

By C. S. Vesey Brown, Assoc. Mem. Inst. C. E.

INDUSTRIAL Britain is at the present time largely interested in the numerous projects sanctioned by Parliament for the supply of cheap electric power from central stations situated in the different districts.

The history of the development of this movement towards the centralisation of power production is of considerable interest from several points of view, but more particularly as showing the gradual education of works managers in the possible economy and efficiency of electric transmission of energy. It is not so long ago that they were convinced that there was nothing "like leather," "Popp," wire ropes, or hydraulics, but now they are crying out for electricity. "Only bring it to our workshops at once and at a reasonable price, and our effete old country will be rejuvenated." Alas! that it should be so, but the majority of the motors required to do this are not "made in England" yet, but no doubt they soon will be when old Trafford and Rugby are in full swing.

It may not be out of place to trace the course of events which have marked the movement to its present stage.

The conception of large central stations for the supply of electric light and power occurred some time in the early eighties, and the culmination of the ideas on these matters took place when Ferranti proposed the erection of the Deptford Works. The experience of high-pressure, alternating-current generation and distribution at that time was sufficient to set electrical inventors thinking as to the best means to utilise the high pressure of his and other alternating-current generators, and after many experiments Ferranti succeeded in transmitting a single-phase, 2500-volt alternating current along a cable about fourteen miles long to drive an alternator turned for the nonce with a motor, but the difficulty of starting the motor was not properly overcome until multiphase currents were proposed and generally adopted. From that time electricity, at anything from 2000 to 50,000 volts with multiphase currents, has been the foundation on which power supply stations have been laid down. America and the European Continent were not slow to take advantage of these discoveries and improvements in multiphase machinery, and central stations, driven by either steam or water, were at once set into motion.

During the period from 1888 to 1897 the efforts at power generation and distribution in Great Britain were mainly confined to small, insignificant applications. A few far-seeing manufacturers, generally those whose business lay in manufacturing electrical apparatus, fitted up their workshops with electrical transmission plants; others contented themselves with applying electric motors to boiler or engine shop cranes, and such tools as were some distance away from the steam plant.

Meanwhile, Niagara had been started, and its success had led American engineers to look out for "fresh fields and pastures new" in Great Britain, and they decided to promote a bill in Parliament in 1897 for the purpose of establishing an electric power station in the centre of the Nottingham, Derby, and South Yorkshire coal field in the neighbourhood of Warsop, and to distribute electric power to anyone requiring a supply within a radius of twenty-six

miles from this point. The magnitude of the undertaking and the proposals for distributing the current raised the powerful opposition of the muncipalities whose works, primarily established for lighting, were threatened, and after a long battle the bill was thrown out by the House of Commons. It is doubtful whether this would have been the case if the question of distributing power had been dealt with on the lines of the existing practice, that is, by separate statutory powers.

American and Continental competition in varied engineering trades had, however, so roused the British public to the possibilities of cheap electric power that in the following two years occurred the great fight between local authorities and the promoters of several bills for the establishment of these power stations all over those parts of England and Scotland practically corresponding to the coal fields. The result of this scramble for electric power rights is a series of Acts of Parliament authorising the supply of electricity in well defined areas under certain conditions as to wayleave through local authorities' districts and a relation between average price and dividend. How far these powers will be exercised it is at present impossible to forecast, as the question of raising the necessary capital and the general system to be adopted to carry out the works are now before those who have obtained them.

The writer ventures to give a general idea of the lines on which these works should be laid out to the best advantage to serve the different localities. It would be a difficult matter to lay down a hard and fast rule which would suit each district, owing to the varied conditions which obtain. First there should be no difficulty in fixing upon the position of the works, for railway communication and facility to obtain water to condense the exhaust steam are the two principal points to consider Another point, not so important, but well worth consideration in choosing a suitable site, is its position to main roads for laying the cables which are to radiate throughout the district.

Having decided on the site, the next question arises as to the pressure of supply, and here distance, combined with the demand, fixes the amount, probably at anything from 10,000 to 20,000 volts. Up to the present time underground cables have not stood the test of time and experience for a greater pressure than the above, though no doubt as the reliability of resinous and other insulating compounds is guaranteed, the pressure may be raised to 50,000 volts. One of the difficulties to be overcome by the adoption of these high pressures is to determine upon the size of generator and at what pressure to generate, and so far a maximum of 10,000 to 11,000 volts in a dynamo of any size is the most that can be guaranteed with any degree of safety. The practice in the majority of the power stations established is to generate at a low pressure, say, 5000 to 6000 volts and transform up to 10,000, 20,000, or even 50,000 volts by stationary transformers, and it may be safer from the point of view of continuity of supply to adopt this latter arrangement.

In the majority of power stations at work all over the world little use is made of underground cables at the extra high pressures. More often than not overhead lines are erected, and it is a question which will have to be faced in the future, whether overhead lines may not be erected and used in Great Britain under proper conditions as to safety for the public. The liability to breakdown from bad weather is a point against the adoption of overhead lines; but, on the other hand, the very heavy cost of insulating and laying underground cables will be a considerable factor in the cost of the supply. Local authorities whose funds are low and who are anxious to repair their roads at someone else's expense, are only too apt to try to enforce conditions which, in the long run, may prove too onerous for underground cables. The question is, at the time of writing, being thrashed out between the London Chamber of Commerce and the Board of Trade, and the latter body are sure to thoroughly safeguard the

local authorities wherever their interests are likely to be threatened.

The size of the unit of plant to be laid down is dependent, to a certain extent, on the type of engine to be used. It is essential that a three-crank engine should be coupled to the generator, and though marine engines with three cranks have been built to develop 15,000 I. H. P., yet the conditions under which they have been adopted do not apply entirely to electric power stations, and, in the writer's opinion, a size of engine somewhere between 3000 and 5000 H. P. is the most suitable.

To each of these units, of, say, 3000 KW, could be connected a battery of six boilers with independent feed-pumps, economiser, steam, and other piping, and by arranging that either of two batteries of boilers could be used on adjacent engines, a convenient system of interchangeableness can be guaranteed. Further interconnection than this for "regular" work would involve considerable expense and complicated pipework, which generally requires constant supervision, and though presumed to be ready in case of emergency, is very often found not ready for immediate service when it is most needed.

The type of dynamo, engine, or boiler to be adopted for central stations is hardly within the scope of these remarks, but it may be confidently stated that nothing in the nature of experiment should be attempted in the choice of the machinery. It very often occurs that engineers whose business has been in one of the kindred branches of engineering are called upon to advise on these vital matters, and though the writer does not discourage the development of new ideas, it must be strongly urged that the ideas should be such as would recommend themselves to those whose business it has been to carry out works either of a similar magnitude or under similar conditions. The price of an article, too, is not always the best test of its merit.

The limit of the power equipment of separate stations has been discussed times without number, and figures of from 5000 to 25,000 horse-power have been suggested by many experts. The size of water power stations is hardly looked upon as a guide, on account of the boilers and engines required for the steam-driven works. In the writer's opinion, there should be no difficulty in arranging the machinery for each station to develop at least 25,000 horse-power. The use of double tiers of boilers and generating units of 5000 horse-power each, should allow of this being done, and by making use of comparatively high speed engines and water-tube boilers there should be no difficulty in collecting this plant and all the auxiliary machinery comfortably on to an acre of land. The switch gear, transformers, underground cables, and other details would furnish enough material for a separate article.

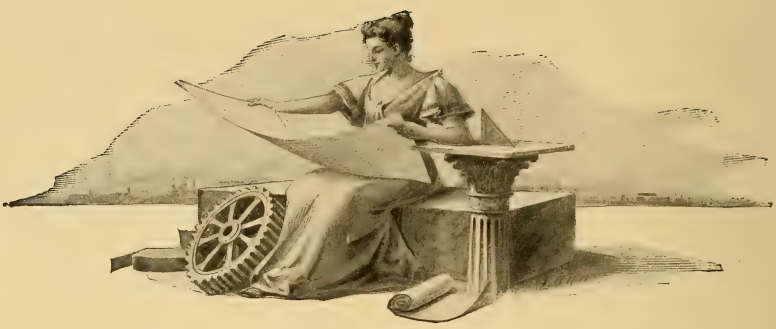
The future of electric power supply from these large central stations in Great Britain is at the present moment a matter only of conjecture, and, if one may say so, is more in the hands of manufacturers than of those who are willing to supply. The sturdy, conservative independence of the British manufacturer who desires to keep the whole of his manufacturing appliances as far as possible in his own hands is one of the great barriers to be broken down, and the process of doing so is sure to be slow. As a rule, the question of taking a supply of power from any existing electricity works commences with a demand for a motor to be connected to some auxiliary pumping, lifting, or ventilating machine, and it is inconvenient for the manufacturer to lay out the capital or provide the power to equip a dynamo for driving the motor in question. He is informed that the price will be 1½d. to 1¼d., or perhaps less, per unit, but this does not satisfy him; he is convinced that it should be done for the bare cost of coal and wages, and is not prepared to consider the great convenience of having the power "on tap." This question will be overcome sooner or later, as power users convince themselves that the supply is regular and constant, and that the supply companies do not make an abnormal profit out of their business.

As regards other developments, which, it may be confidently expected, will take place when there are great trunk lines of cables traversing the villages and small towns which abound in all the districts covered by the Power Acts already granted, it is not too much to say that each village or town will be better, cheaper, and more efficiently lighted than heretofore. Dwellings where oil lamps are now used will be supplied through slot meters, giving from five to seven hours for each lamp for one penny; and that there may be some chance of the solution of the problem of how to bring back the population from the great towns to the villages by a free use of small electric motors to encourage home industries, there should be a quick, cheap, and efficient electric tramway service throughout the country districts, giving access to the main railway arteries between the great towns.

Another point which should not be lost sight of in the equipment of power stations is the conversion of the existing steam railways to electricity. This is not so far in the future as is generally supposed. The success of the high-pressure electric railways established in Germany and Austria by the great Continental firms of Messrs. Siemens & Halske and Messrs. Ganz & Co., is practically assured, and though it may mean that many portions of the railways may require straightening-out to allow of higher speeds, the conversion is bound to come, and it behooves the designers of power stations to consider how far their plant should be arranged to supply the demand when it arises.

Agriculture in Great Britain has, of late years, received much assistance in order to enable the "backbone of the country" to struggle for an existence and livelihood against foreign competition, and there is every reason why some benefit should accrue to the farmer from the use of electricity in the various operations connected with his calling. The experiment now being conducted in Bohemia and the increasing demand being made there for electric ploughing and reaping outfits is an indication that the question is receiving the fullest consideration from Continental manufacturers and landowners alike.

The limit of electric power supply has not yet been dreamt of. Every day brings fresh indications as to the extent of the operations which may be carried out by its aid, and by degrees the country will be split up into districts analogous to the great railway and water supply systems, each with its distinctive features necessitating peculiar arrangements to deal with them.



Current Topics

THE value of having clean tidy, well-lighted, and well-warmed workshops is impossible to determine in figures; but it is, nevertheless, real and very substantial, and this is the belief and experience of a daily increasing number of shop managers. In a paper presented at the recent Glasgow International Engineering Congress Mr. William Thomson referred to it as one of the factors governing the economical manufacture of marine engines, and made the point besides that one cannot have a clean shop when the shop is badly lighted. Accordingly, in one instance it was decided first to get rid of the old earthen floor which is so common in British works and to cover the whole of the ground floor with granolithic and concrete pavement. The improvement was most marked. Formerly, with the old earthen and iron-chip floor, it was impossible to keep anything clean. Dirt and dust were the order of the day if the floor had to be swept, and it was, therefore, generally left alone as long as it could be tolerated. Now there is no trouble, but instead a fine, smooth, clean, bright surface to move about on. The floor is from 9 inches to 12 inches thick in most places, and below machines somewhat thicker, and consists of about 2 inches of rough bottoming of broken stone, then 6 inches of concrete of 5 to 1, and a top finish, 2 inches thick, of facing made of granite chips and cement in the proportion of 1½ to 1. As it sets, it is levelled and smoothed off with a trowel, and in three days is ready for use, becoming quite hard in about a week, and when thoroughly set the floor assumes a beautiful light surface, with the effect of reflecting the light and perceptibly aiding the general lighting of the shop The new floor is easily swept and kept clean, is easily repaired, and, Mr. Thomson says further, does not wear into hollows; nor has there been complaint from the workmen that it is tiring to the feet.

THE benefits of having a well-lighted shop are pretty generally recognised, but, still, not to the extent that they might be. There are still a great many places,—some of them of the first rank,—without adequate means of lighting. This is more generally the case in boiler shops than in machine shops, though if there be a place where there ought to be good light it is in a boiler shop. As to the problem of warming a shop, it may not be amiss to note that in Great Britain the range of temperatures is not

nearly so great as in the United States, and the want of proper heating facilities does not, therefore, become one of daily experience with the British works manager. This may explain also why so little has been done in this direction in Great Britain, though, admittedly, more attention to this detail of works practice is urgently required in many cases. The idea which used to be very prevalent, especially in boiler-making lines, that a cold snap made men work all the harder in order to keep themselves warm, is happily exploded, and a more rational view is now likely to be taken of this hitherto much neglected subject.

ABOUT twenty years ago a patent was obtained for a freak of locomotive construction which is one of several interesting illustrations of the occasionally curious workings of the patent office. This particular locomotive had independent drivers; that is to say, the cylinders were to be placed between two pairs of driving wheels and the piston-rod in each case was to extend through both cylinder heads and carry a connecting rod at each end. With this remarkable arrangement the effect of the angularity of the connecting-rods was entirely ignored. When the forward and after wheels, for example, had their cranks on the dead centers, and if the connecting-rods and piston-rods were of the right length, the distance between the two cranks was at a minimum, and it would have been impossible to get them off the centers without straining something or bringing the axles together. It seems almost needless to say that the engine was never built.

THERE was dedicated within the past few weeks, at Titusville, Pa., a memorial to Colonel Edwin L. Drake, the man who drilled the first oil well and the founder of the petroleum industry in the United States, which is estimated to have added about $2,000,000,000 to the wealth of the country. Colonel Drake died in comparative obscurity about twenty years ago, and since that time the matter of a suitable monument to his memory has been frequently discussed, with no result until now, at last, through a secret donor, the pioneer oil man has been honoured in a fitting manner. It is interesting at this time to recall some of the principal points in Colonel Drake's career. In 1857 he was a conductor on the New York & New Haven Railroad. He had invested in the stock of an oil company that had a lease of some land near Titusville on which there was an oil spring, and he was deputed by larger stockholders to visit the property Up to the time of Drake's visit oil was gathered from the springs and pits by skimming, and sold mainly as a liniment at twenty-five and fifty cents a bottle. It was an Indian remedy, and known as Seneca oil. A visit to the salt wells at Tarentum suggested to Drake the idea that more oil could be obtained by drilling a well, and he carried out the project, in the face of opposition and discouragement.

ALTHOUGH work was begun on the well on May 20, it was not until August 12 that bedrock, 36 feet 4 inches from the surface, was reached. Colonel Drake finally conceived the idea of driving an iron pipe to bedrock, thus shutting off the water, clay and quicksand. He had no idea as to the depth at which oil might be found. He was out of funds, discouraged, and had it not been for David Fletcher, a merchant of Titusville, and Peter Wilson, another friend he had made in Titusville, it is doubtful if he would not have given up in despair. Fletcher and Wilson tided him over by indorsing his note for $500, which was secured from a Meadville bank. Progress was made at the rate of a trifle more than 2 feet a day. Many visitors came to see the work, but they treated the project largely as a joke. But Colonel Drake had some faith in his heart and some borrowed money in his pockets, and the drill kept working its way through the rock.

On Saturday afternoon, August 27, 1857, the drill, at a depth of 69 feet, dropped 6 inches into a crevice. Down in the salt well country crevices were common enough, and nothing was thought of it. But when the tools were withdrawn from the well there was oil on the rope. A piece of tin spouting was fitted up and lowered into the well, and in this way several gallons of petroleum were bailed out with it. On Monday a pitcher pump was put on and several barrels full were pumped out by hand. A man was sent to Pittsburgh for copper tubing, such as was used in salt wells, and in a few days the well was rigged up for pumping with an engine, and pumped night and day, producing more than twenty barrels a day for two or three years.

THE news of the strike spread all over the country and thousands of visitors travelled far to see the wonderful sight. Every farm for miles around was quickly leased. Colonel Drake appeared to think that he had hit the fountain head, and made no effort to get more land. Then he threw away a fortune in not securing a patent on his drive-pipe idea. When the Drake well came in it broke the liniment market, and Drake himself was quick to realise that another market must be opened for the product of his well. He sent some of the oil to Pittsburgh and had it refined. The first lot of ten gallons was received at Titusville on November 15, 1857, and retailed at $1 25 a gallon. With it came a shipment of lamps in which to burn it. It was known as carbon oil. A second shipment of forty gallons retailed at $1.30 a gallon, the wholesale price being 80 cents a gallon.

THE strangest thing about the Drake well is that it was the shallowest oil well ever drilled in Pennsylvania. Other wells drilled about it vary from 200 to 600 feet. If a thousand wells had been drilled to its depth along Oil Creek every one of them probably would have been as dry as a powder horn. The explanation is made by Daniel Fletcher, Colonel Drake's closest friend, that in drilling the Drake well the drill fortunately tapped a crevice that led down to the oil rock, and that it was through this crevice that the oil spring was fed from the rock. Colonel Drake never made much money out of the petroleum industry. Other and larger wells came in, and the price of oil dropped from $20 a barrel to 10 cents. In 1860 he was elected Justice of the Peace in Titusville, an office that paid about $3000 a year then. He bought oil on commission and dealt in real estate. With about $15,000 he left Titusville in 1863 and went to New York, where he lost his money in speculation. Then his health gave way, and he lived in obscurity, poor and friendless. Titusville people learned of his misfortunes and quickly subscribed several thousand dollars. In 1873 the Legislature of Pennsylvania voted him an annuity of $1500. The family settled at Bethlehem, Pa., in 1870, and there, in November, 1881, Colonel Drake passed away.

PERIODICALLY the question is asked why there is nothing available in the shape of a small ice or refrigerating machine for domestic use. That such a machine is in wide demand and would meet with a ready sale is generally admitted, so that to many it seemed all the more curious, no doubt, that commercial enterprise did not long ago undertake to solve the problem. The whole question, however, may be answered by the statement that no better method of refrigeration has yet been found than the use of ammonia or a similar system, which involves the use of certain pressures and a certain number of elements in the cycle, such as compression, expansion, and condensation, regardless of whether the plant is to turn out a fraction of a ton or a hundred tons. The supervision of the refrigerating cycle and the safe manipulation of pressures requires skill,—in fact, a skill somewhat above the average, and

which cannot be expected from ordinary domestics. It, therefore, seems that the facts as they stand at present preclude the possibility of small domestic ice or refrigerating plants, and will so continue until some system may be devised differing widely from any now in use.

In very long electric power transmission lines the highest possible potentials are necessary in order to restrict the investment required. This, indeed, is one of the elements of transmission design, and does not need special emphasising. But when the voltages go above 30,000 volts phenomena arise and become important in the problem of insulation which it was unnecessary to consider below that voltage. Referring to these in a recent paper read before the American Institute of Electrical Engineers, Dr. F. A. C. Perrine stated that, in the first place, voltages from 25,000 to 30,000 volts can be readily handled with insulators of either glass or porcelain of a diameter not exceeding 7 inches. Pieces of glass or porcelain of these dimensions are mechanically strong, and are readily manufactured. Where the voltage rises to 50,000 and 60,000 volts, and the sparking distance between the lines increases to between 5 and 6 inches, the insulators must have a diameter of at least 12 or 13 inches, and should be held not less than 7 or 8 inches above the cross arm. Such pieces of these fragile insulating materials are difficult to manufacture, and while the problem has been successfully solved, the greatest care in design and manufacture is absolutely essential, though it is believed that the factor of safety of high potential insulators as at present designed is by no means as great as that commonly employed with the lower voltages. An even more striking difficulty in handling high voltages lies in the effect of the electrical surface tension, which, with high voltages and small wires, results in a brush discharge and high energy loss independent of leakage over the surface of the insulators, being simply an escape to surrounding bodies from the whole surface of the wire. Stated simply, it is found that the electrical tension along the line operating at 50,000 or 60,000 volts renders the use of wires smaller than about $\frac{3}{8}$-inch in diameter a dangerous expedient, resulting in important losses, which again points to the fact that high potential, long-distance transmissions cannot be successfully carried out unless the power to be transmitted is in itself large, warranting the use of conductors of great size.

In long-distance transmission work extraordinary precautions must also be taken to maintain the permanence of supply. Long-distance transmission means large powers, and large powers delivered at distant points presuppose important engineering undertakings at the delivery end of the line which call for absolute continuity of supply. The poles must be selected and erected with more than ordinary care. The lines must be constantly patrolled. Trees cannot be simply trimmed, but a right of way, almost as wide as a railroad right of way, must be secured, and all obstructions of the nature of trees, which may fall across the line in high winds, must be removed. The use of the ordinary insulating materials in power houses and supply stations, such as paraffined wood and paraffined marble, must be entirely abandoned or relied upon only as minor auxiliaries, and, finally, wherever it is possible, either steam or storage battery auxiliaries at the delivery end of the line should be furnished. The engineering problem, by its very bigness, is one requiring the most careful solution at every step, and the fact that it is being now successfully carried out merits the highest praise both toward the engineers and designers, and the investors whose faith in their engineers permits the employment of the necessary capital to do the work thoroughly.

At this time, when anthracite is less extensively used as a blast-furnace fuel

than it was a generation ago, and managers endeavour to maintain regular and known ore mixtures, the "freezing" of tuyeres, cinder notch or iron notch is infrequent, and, consequently, the oil burner or "kerosene blowpipe" is seldom employed. Furnace foremen have also, to a considerable degree, forgotten their former cunning and persistency in the use of the drill and sledge. Still, in starting new or abandoned plants with untrained labour, and in running some of the large 100-foot furnaces, slips, resulting in very cold furnaces, may occur, even under experienced managers. In a paper presented at the meeting in Mexico, last month, of the American Institute of Mining Engineers, Mr. F. L. Grammer told that in one case such a misfortune was experienced, owing to a dearth of trustworthy foremen, and the electrician of the works proposed to open the tuyeres and cinder notch by means of the heat of the electric arc. It has been said that the surface cracks or marks developed in rolling heavy plates have been closed by electric welding, as by a soldering iron, and also that an electric burner has been employed at some German blast furnaces; but the experiment was quite novel in this particular instance.

In the construction of the circuit one wire was attached to a pipe feeding a cooling block of the furnace wall, some distance from the point where the burner was applied. The current from this wire passed either through the crucible or through the circumferential shell. The other wire, after running through a resistance coil immersed in a barrel of water, was attached to clamps holding the carbon, the latter being inserted in an iron pipe provided with a wooden handle, and applied at the desired point by the goggled operator. The first experiments were not very successful. The carbons used were 1½ inches in diameter and 18 inches long,—the largest obtainable at the time. Subsequently special carbons were made, 4 and 6 feet long, and with these a hole was burned through 18 inches of cold iron in about five minutes. A current of from 400 to 500 ampères did the work, but 1000 ampères, at eighty volts, gave better results. Altogether, these were so satisfactory that permanent wires were strung up to the furnaces, and "hard holes" at tapping time, requiring slackening of wind, are now an evil of the past. The electric current employed is not dangerous to the workmen; and the apparatus, unlike the oil blowpipe, is always ready for service. It can be applied instantly to a black, cold surface, without the need of any blast pressure,—a boon which will be appreciated at single stacks, where the freezing of the tuyeres may have made it difficult to get the necessary pressure by affecting the gas supply to the boiler house. Mr. Grammer concludes by saying that the saving in oil, wornout men, drills, and time commends this simple and effective burner as the best.

In discussing the choice of motive power for operating the machinery of gun mountings aboard ship,—the elevating and training gear, the means of supplying the gun with ammunition, etc.,—Lieutenant A. Trevor Dawson, of the Vickers Company, recently spoke of the importance of avoiding any system which will cause the lower deck and compartments in a ship to become heated, especially as there is usually great difficulty in ventilating such places to make them habitable. Steam-engines with their pipe leads, valves, etc., which must radiate much heat, are impracticable from this cause alone; but, in addition to this disadvantage, they are next to impossible inside a turret, owing to the danger of the gunners being scalded in the possible contingency of joints being damaged or pipes broken in action. Compressed air has one great advantage in comparison with steam. No return-pipe system is required, as all machines may exhaust nto the atmosphere, and by so doing

materially assist in the ventilation of the turret. The noise, however, made by the free exhaust is very objectionable. Compressed air, to be economical, must be worked at a very high pressure, and a damaged pipe might, therefore, cause a rupture, with serious results. Electricity, when compared with steam and air, has many advantages. On the other hand, there are a number of serious disadvantages involved. All electric motors of reasonable weight and size for the purpose must run at a very high speed, necessitating heavy gear trains, which involve much loss of power and a great deal of noise. Difficulty, too, is frequently experienced in discovering the cause of failure which occasionally occurs either in the motor, controller, or conductors. Hydraulic power has practically none of the disadvantages enumerated for the other systems of power described. Pipes can be laid anywhere, they give out no heat, if they are damaged no explosion takes place, and the damage can easily be discovered and quickly repaired. They work practically in silence. The vertical and horizontal running of the gun is under perfect control, and the dead slow movement required is obtained with the greatest facility and precision.

THE higher cutting speeds and heavier feeds which have latterly been imposed on machine tools have naturally increased the stresses on them very greatly, and have emphasised the need of greater power and greater massiveness of construction all around. In lathes and boring machines particularly, said Mr. William Thomson recently before the Institution of Mechanical Engineers, cutting power is not in proportion to capacity, and want of belt power is a fault more often met with than not in machines of all classes. In one instance, several years ago, a certain tool made by a first-class firm was purchased, and after repeated trials it was concluded that it had not adequate belt power; so when a second machine was ordered, an increase in the ratio of gearing of about 28 to 30 per cent. was insisted upon, much against the will of the toolmakers, who considered that the first machine was amply powerful. The result is that the newer machine turns out the same work as the old in 26.5 per cent. less time.

HON. ABRAM S. HEWITT

A BIOGRAPHICAL SKETCH

By R. W. Raymond

ABRAM STEVENS HEWITT was born on July 31, 1822, at Haverstraw, Rockland County, New York. The time and place of his death, nobody knows (thank God!) for the simple reason that he is still, to the great benefit of his countrymen and the daily satisfaction of innumerable friends, very much alive. It is, indeed, on account of that circumstance that I embrace, with as much enthusiasm as a tired man can feel, the opportunity to prepare this brief ante-mortem sketch of him. For I am weary of expressing over the graves of colleagues, distinguished and beloved, the personal appreciation and the public verdict to which their lives entitled them.

Mr. Hewitt came of the best stock on both sides. His father, John Hewitt, was an English mechanic and pattern maker concerning whom the single circumstance known to me is peculiarly significant; namely, he was chosen, when but eighteen years old, as one of the four men sent from the famous Soho works of Boulton & Watt, in the last decade of the eighteenth century, to set

up, at the Centre Square waterworks in Philadelphia, the first steam-engine ever seen in this country Considering the unique novelty and importance of this task, and the small number of those to whom it was intrusted, one cannot but feel that the youth of eighteen thus selected must have possessed no ordinary qualities, moral as well as mental. Shortly after (1793-4), at the small machine shop attached to the Schuyler copper mine, near Belleville, N. J., the young pattern maker assisted in the construction of the first steam-engine ever wholly built on this continent. It is an interesting coincidence that the subject of this sketch is thus ancestrally connected with the marvellous industrial development of the United States, of which our mineral resources have been the essential basis, in which the steam-engine has been a prime factor, and to which Mr. Hewitt himself has made contributions of supreme importance.

The young English mechanic, wisely deciding to risk his fortunes with the young republic, settled in the State of New York, and took a wife from a French Huguenot family, bearing the name of Garnier, which, in the modified form of Gurnee, is now well known in the business and social circles of New York. This blended parentage might well be expected to exhibit, in the next generation, a combination of sturdy independence and self-reliance with refined tastes, conscientious motives, and generous impulses.

Abram S. Hewitt began his education in the public schools of New York City, where he won, as the result of a competitive examination, a scholarship in Columbia College. Throughout his college course he stood at the head of his class, and with that rank he was graduated in 1842. Although the scholarship which he had earned relieved him from dues for tuition, he was obliged to support himself, in other respects, by extra work as a teacher; and at the time of his graduation he was already, though but twenty years of age, a regular tutor of mathematics in the college. If I am not mistaken, it was in this capacity that he made the acquaintance of Edward, the only son of Peter Cooper. In 1844, being forced by serious trouble with his eyes to suspend his college work, he accompanied Edward Cooper on a trip to Europe,—the voyage being, of course, made by sail. During their return they were shipwrecked in mid-ocean, and rescued by a ship which caught sight of the little boat in which they were adrift. Such a common experience naturally cemented a friendship which still endures unbroken, having been still more closely compacted by the association of the two in business, at the request of Peter Cooper, and by Mr. Hewitt's subsequent marriage (primarily, no doubt, at his own request!) with Peter Cooper's only daughter.

It was fortunate for Peter Cooper that his son and his son-in-law took charge of his business when they did. For he was a business man of the old school and the small scale, accustomed to superintend all details himself, and very largely to keep the particulars of his business situation "in his head." His industry, honesty, frugality, and inexhaustible inventive genius had built up a business greater than his primitive methods could handle. But he wisely acquiesced in the changes required by new commercial conditions, and lived to see them amply justified by results.

One of these changes was the removal to Trenton, N. J., of a wire mill owned by Mr. Cooper, and occupying in New York City a site no longer suitable. In its new location this mill became the nucleus of the large business subsequently developed by Cooper & Hewitt, and represented by the works of the Trenton Iron Company and the New Jersey Steel and Iron Company, at Trenton, and the iron blast furnaces at Phillipsburg, Ringwood, and Pequest, N. J., and Durham, Pa. For many years the firm was a leading representative of the iron manufacture of the United States. It was the first American concern to make iron beams and girders, and the third to roll iron rails. Its blast furnaces at Phillipsburg were regarded, in their day, as models of excellence, and long "held the record"

for yield of pig-iron. As late as 1876 their Durham furnace was recognised as embodying the best construction in anthracite blast furnaces, and, for this reason, was elaborately described and illustrated in London *Engineering* by no less an authority than Alexander L. Holley, and in the transactions of the American Institute of Mining Engineers by other authors of repute.

Foreign, as well as domestic, improvements were discerned and promoted by this firm. In 1856, within sixty days after the reading in England of Bessemer's famous paper, an experimental Bessemer converter was running in the works of Cooper & Hewitt at Phillipsburg. This experiment, it is true, had no immediate practical result of value. In fact, it may be said to have failed, as did similar first experiments elsewhere. Yet it deserves mention as evidence of the alert intelligence with which Mr. Hewitt noted and appreciated every sign of progress in the metallurgy of iron and steel, at home and abroad.

But the next important illustration of this characteristic quality did not end in failure. Mr. Hewitt, as United States Commissioner to the Paris Exposition of 1867, made a report upon the iron manufacture and trade of the world as there exhibited, and the bearing of that exhibition upon the actual and prospective iron and steel industry of this country, which took at once the position it still holds as a classic in the literature of its theme. It was, indeed, only the first of a series of equally noteworthy (though, perhaps, less widely famous) utterances of criticism and prophecy which history has already verified. But he did not stop with words. Recognising the value of the new open-hearth method of steel manufacture, as shown at Paris by the Martins, he undertook its introduction into this country, acquiring control of the Martin patents, erecting at Trenton the first American open-hearth furnace, and urging upon manufacturers in every possible way the merits of the new method, then questioned, but now universally acknowledged.

Still later Mr. Hewitt interested himself in the invention of Mr. G. J. Snelus for the use of basic linings, which, combined with the subsequent improvements of Thomas, became the foundation of the "basic" processes, now so widely and successfully used. It was for these and other services to the progress of the iron and steel manufacture that the Iron and Steel Institute conferred the Bessemer Gold Medal upon Mr. Hewitt in 1890.

Turning from this inadequate sketch of one department only of Mr. Hewitt's long activity, I must make mention,—even less fully and fairly, I fear,—of his political career. Though always an active and eminent member of the Democratic party, he gave to the government, during the War of the Rebellion, a hearty and effective support. In fact, the works of Cooper & Hewitt were for four years practically devoted to the public service in the manufacture of gun-barrel metal and other munitions of war, without profit to the owners, but with great advantage to the Union cause, as the War Department repeatedly acknowledged Perhaps the most striking instance of such service was the rapid construction at these works in 1863, by a veritable *tour de force*, of the mortar-beds for General Grant's expedition against Fort Donelson, and for the fleet of gunboats which, under Commodore Foote, subsequently opened the Mississippi River. It was believed at the time that the prompt supply of these mortar-beds saved from failure both of the military operations mentioned.

In 1875 Mr. Hewitt held office for the first time, as a Representative from New York in the Forty-fourth Congress. This position he retained by successive re-elections for twelve years, resigning it in 1887 to become Mayor of New York. His career in Congress was both eventful and useful in the highest degree. Differing freely and often with the prevailing tendencies of his party, he was, nevertheless, its guide in many matters, and was able to shape much wise legislation. Among the objects of his Congressional work may be enumerated:—

1. The improvement of the consular and diplomatic service.

2. The resumption of specie payments, a repeal of which step was successfully opposed and prevented by him.

3. The overthrow of the "free-silver" heresy, which he sternly opposed, even making, in 1876, an exhaustive argument to show the dangers of the Sherman compromise upon "limited" silver coinage, then impending, which, in fact, deranged for twenty years the business of the country and increased the final difficulty of a return to sound financial principles.

4. The unification of the various geological surveys of the United States, and the creation of the Geological Survey, which is now, in a systematic manner, covering the whole of this field.

5. The advocacy of liberal revenue legislation, and especially of free raw materials for manufactures. Mr. Hewitt's course in this respect was naturally opposed by the extreme Republican protectionists, while, naturally also, it alienated the extreme free-traders of his own party. But he was really following Hamilton's theory of protection, which he had always held, and which, in its essential principles, recognises the wisdom of low duties (and even no duties), and of commercial reciprocity apart from all general formulas, according to the conditions of each period and each concrete problem of policy. Mr. Hewitt's speech of 1886, on the Mexican treaty, was a clear utterance in favour of the reciprocity then opposed by Blaine, McKinley, and Reed, but subsequently favoured by all of them, and now asserted as the Republican policy.

6. Outside of all general theories or party platforms, Mr. Hewitt's thorough knowledge of business, as well as finance, was valued by both sides, and freely placed at the service of both. The administrative reforms successively embodied in the Morrison, Mills, McKinley, and Dingley Tariff Acts were his work; and Mr. McKinley, in his famous speech in advocacy of his own bill, frankly acknowledged the services of Mr. Hewitt in this particular.

A circumstance which occurred while I was in Mr. Hewitt's employ furnished an amusing instance of the confidence with which both friends and foes in the political sphere were accustomed to appeal to him for advice. It was during the later tariff debates, in the House of Representatives, and, if I mistake not, soon after Mr. Hewitt resigned his seat in Congress, that a telegram from Washington was received at his New York business office, running as follows:—

HON. ABRAM S. HEWITT—Does the producer or the consumer pay the duty? Answer immediately.

The name signed to this naïve inquiry was that of a leading Democrat, frequently self-exhibited and generally recognised as an opponent of "protection," even in the moderate and progressive form in which it was advocated by Mr. Hewitt That after many public contributions, of authoritative tone, to the literature of the subject, this distinguished legislator should need information concerning its alphabet, was amusing enough; and when, in Mr. Hewitt's temporary absence from the city, this telegram, with other communications calling for immediate reply, was brought to me, it presented a temptation which I could not resist. So I sent the following reply:—

HON. ——— ———, HOUSE OF REPRESENTATIVES, WASHINGTON, D. C.—Sometimes one; sometimes the other.

A. S. HEWITT.

I never knew whether Mr. Hewitt thought it necessary, on his return, to follow this telegram with further elementary instruction by mail. At all events, I know of no further attempts to obtain from him by means of the telegraph the fresh condensed milk of political economy for immediate use! Joking apart, however, this question, and my answer (which was, I think, a fair epitome of Mr. Hewitt's position), illustrate the radical difference between his standpoint and those of the doctrinaires of both parties in Congress.

7. As a representative of the metropolis, he secured the appropriations necessary for the deepening of the ship-channels, and induced the Federal Government to commit itself to the sys-

tematic and extensive improvement of New York Harbour, which has been steadily prosecuted ever since.

8. In 1876 Mr. Hewitt, as chairman of the National Democratic Committee, had charge of the Tilden campaign, in which the "literary bureau," organised by him, received general commendation. He was a member of the special Congressional committee which framed the bill for an Electoral Commission to settle the disputed result of that contest; and, in the House of Representatives, he led his party in accepting and executing the provisions of that bill. To him, more than to any other man, was due the peaceful settlement by which a great national peril was escaped.

In 1887 Mr. Hewitt resigned his Congressional position, to become Mayor of New York, after a memorable contest, in which the late Henry George was the opposing candidate. His work as Mayor consisted chiefly in restoring efficiency to the city government and in securing the proper revenue from the municipal resources and property. Tammany Hall, which had supported his candidacy as a choice between two evils, soon developed an active opposition to his absolutely non-partisan administration, and was able, under the legal limitations then surrounding the Mayor's power, to thwart many of his plans and measures. Nevertheless, at the close of his term, he left the machinery of all the departments in a satisfactory condition of efficiency and ready for further enlargements of scope and power. And, besides this administrative improvement, he managed to impress upon his fellow citizens worthy ideas of future metropolitan development, such as ordinary reformers, intent on stopping leaks and abuses, are often afraid to propound. His characteristic practice of issuing, not merely one annual message, covering with vague generalities more topics than the public could at one time suggest, but a series of important messages, each devoted to a single subject, and presenting that subject so forcibly as to command popular attention, contributed greatly to the political education of the whole community.

A striking illustration is the plan for rapid transit, which he formulated in one of these notable messages. It was opposed by Tammany Hall, but subsequently, under the pressure of public opinion, was adopted by the Legislature; and it is now, with the support of all classes in the community, in process of execution. Its main feature is that the work, constructed with the money, and being actually the property, of the city, shall be leased to a responsible corporation, at a rental covering both the interest, and a sinking fund which would in fifty years repay the principal, of its cost; so that, at the end of that period, the whole rapid transit system will be the property of the city, free of all cost, even in the way of taxes *ad interim*, and equally free from all obligations to any private or corporate interest. A fairer, wiser, or more ingenious solution of the difficult problem of disposing of a great public franchise it would be difficult to imagine. If something of this kind had been done with regard to the elevated and surface railroads of New York, how great would be the gratitude of the next generation! The Chamber of Commerce, recognising the great public service of Mr. Hewitt in this respect, recently presented to him a gold medal in commemoration of it; and probably this will be regarded hereafter as the most important achievement of his public career, judged, as men are prone to judge, by results, rather than by arduous labours or heroic sacrifices.

But that is not the only, or the highest, standard of measurement; and, to my mind, the most meritorious (and in the long run, the most fruitful) of Mr. Hewitt's numerous activities has been his patient, wise, and incessant, though unheralded, administration, for more than forty years, of the affairs of the Cooper Union, of which he has been from the beginning, and still is, as secretary of the board of trustees, the executive manager. The credit for this great institution,—a pioneer of its kind,—has been justly given to Peter Cooper; but he would have been the first to acknowledge the essential service rendered

by those trustees to whom he entrusted his work, and who shaped, organised, and administered it, with his approval, so long as he lived, yet not at all in accordance with the crude features of his original dream of it. For particulars, I may refer the reader to my "Life of Peter Cooper." Let it suffice to say here, from personal knowledge, that while the inspiration of this great enterprise came from the heart of Peter Cooper, the wise and effective execution of it is chiefly due to the ability and devotion of Abram S. Hewitt.

I need hardly add that Mr. Hewitt has been identified with all public movements for education or charity, and that his occasional public utterances on these subjects have been marked by a rare combination of sagacity with sympathy. He has been twice president of the American Institute of Mining Engineers, was elected one of the first honorary members of the Iron and Steel Institute, and is an honorary member of many other scientific associations. In 1887 he received from Columbia University the degree of LL.D., and, at the present time, he is chairman of the trustees of Barnard College.

Being now in his eightieth year, Mr. Hewitt is engaged in winding up, as far as may be, the numerous enterprises in which he has been engaged. He is still connected with the iron business, but expects to sever that relation soon. His legal residence is now at Ringwood, N. J., where an estate of 20,000 acres, formerly the locality of a charcoal-iron industry, still offers, in the mining of iron ore and the cutting of ice for the city markets, sufficient business to occupy his attention, while picturesque woodland scenery and an attractive residence offer that restful and peaceful enjoyment which has been so amply earned by a busy, useful, and honoured life.

PHOTO BY FEELEY, NEW YORK

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NIAGARA FALLS POWER

THE ORGANISATION OF THE OPERATING DEPARTMENT OF THE NIAGARA FALLS POWER COMPANY

By Philip P. Barton, Superintendent of the Operating Department

ONE of the many new problems encountered in the prosecution of the great work undertaken by the Niagara Falls Power Company was the selection and organisation of a force to operate and maintain a power plant capable of delivering continuously electrical energy to the amount of 50,000 H. P. In comparison with the magnitude of the output of this plant, the number of operatives required to handle it, as will be shown later, is astonishingly small, and their organisation is less complicated than that required for conducting the operation of any one of many long established plants for the development and distribution of electrical energy for light and power in large cities. Whatever interest the solution of the problem may possess is due, therefore, not to the overcoming of any peculiar inherent, or unprecedented difficulties, but rather to the magnitude and novelty of the plant, and to the importance, variety, and extent of the interests involved.

It is difficult in a few words to convey a realising sense of the measure in which the safety, comfort, and prosperity of almost the entire population of the northwestern corner of New York State has come to be dependent upon the

ONE OF THE PATROL BOXES ON THE TRANSMISSION LINE

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A STRAIGHT-AWAY STRETCH OF THE TRANSMISSION LINES. EMERGENCY WAGGON AND CREW IN FOREGROUND

revolutions of the mighty wheels of the great power house at Niagara. It supplies the energy for every arc and incandescent light in four cities, having a combined population of nearly 500,000 persons. It furnishes the motive power for every street car moving in and between these cities over 350 miles of track. The Pan-American Exposition realised its crowning beauty in 200,000 glow lamps fed by Niagara power. In Buffalo, the Tonawandas, Lockport, and Niagara Falls are fifty large and important manufacturing establishments, representing an investment upwards of $100,000,000, whose successful operation depends absolutely on the continuous supply of power from this plant. In many of these industries the processes are such that an interruption of power service, even of short duration, means great loss of product, disarrangement of process, and, in some cases, costly damage to plant. Since the power plant is the sole source of the energy which vitalises interests of such moment, the responsibilities imposed upon the men to whom are committed the operation of the plant and its maintenance are evidently of no mean order,

and the question of their selection and systematic organisation is worthy of the most careful thought and study.

In March, 1898, Mr. L. B. Stillwell, then electrical director of the company, was commissioned to organise and take charge of a force for the operation and maintenance of the entire power plant. At that time three 5000 H. P. generating units were in commercial operation, and the installation of five others was rapidly approaching completion. Two additional units were contracted for in the fall of 1898, and the organisation established in January, 1899, was designed to take care of the present completed plant, comprising the ten 5000 H. P. generating units in Power House No. 1, together with the necessary local and long-distance distributing systems, and various sub-stations for performing

REPLACING A DEFECTIVE INSULATOR ON A 22,000-VOLT LINE

required transformations of the energy delivered to them.

In laying out the organisation, the objects aimed at were:—

1.—To insure the continuous and uniform supply to each tenant of the full amount of power to which he is entitled;

2.—To provide for the constant maintenance of every part of the plant in the best possible condition;

3.—To provide for the immediate repair of any part of the plant damaged by accident or otherwise;

4.—To limit the annual expenditure for operating expenses to the lowest amount compatible with the complete attainment of these results.

It was realised that these objects could be attained only by an organisation thoroughly systematised throughout, having a responsible head on duty at all times, and in which the respective authority and responsibilities of the various employees must be perfectly definite and clearly understood by all concerned. Considerations to be mentioned later led to the establishment of an eight-hour day for the operating force proper, and this force was accordingly divided into three equal eight-hour crews, or shifts, each comprising a completely organised body of men, with a

BY SPECIAL ARRANGEMENT WITH DR. F. P VAN DENBERGH, BUFFALO, N. Y.

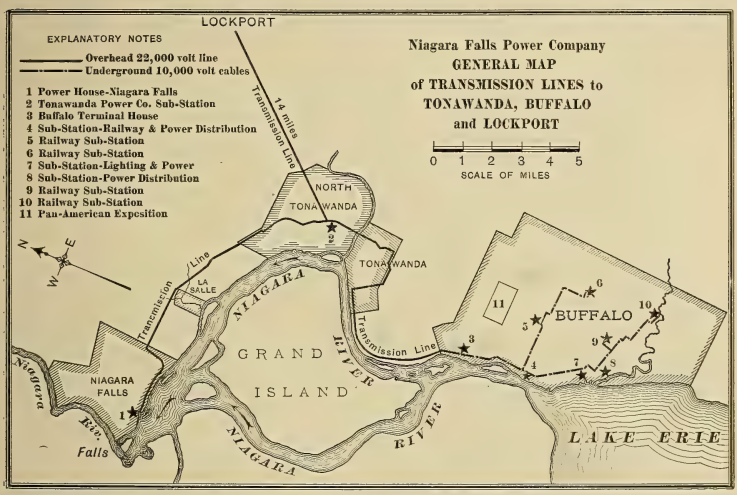
A BIRD'S-EYE VIEW AND SECTION OF THE NIAGARA INSTALLATION. THE DISTANCE FROM THE BEGINNING OF THE TUNNEL AT THE WHEEL PIT TO THE POINT OF DISCHARGE INTO NIAGARA RIVER BELOW THE FALLS IS ABOUT ONE MILE

responsible head reporting directly to the superintendent. The maintenance and repair force divided itself naturally into three departments,—one for the care of the hydraulic or motive power plant; one for the care of the electrical plant, including the underground distributing system and the local sub-stations; and one for the overhead long-distance distributing system.

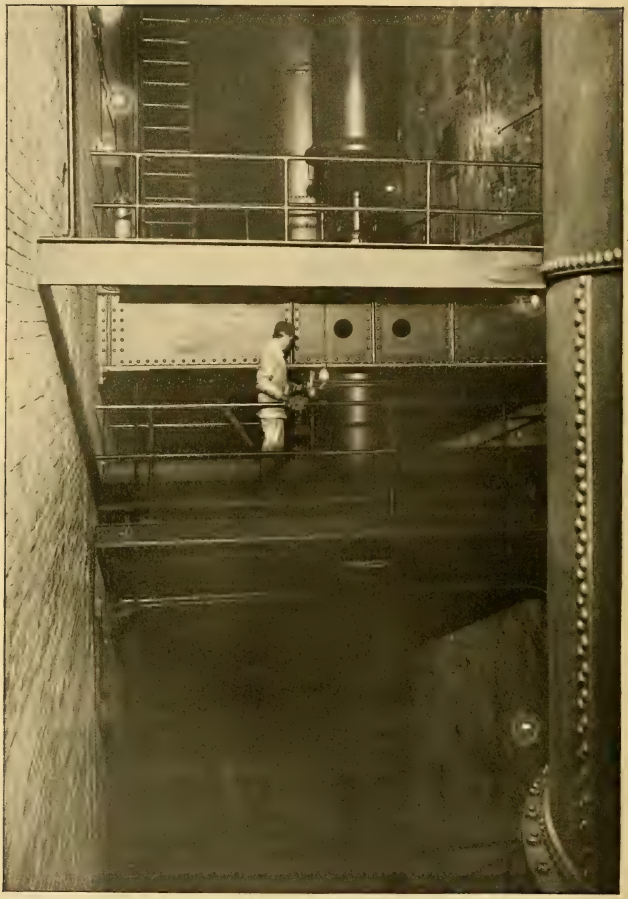
Experience in the operation of the three-machine plant was sufficient to indicate the number and general duties of the employees required for the completed plant, and in the light of this knowledge and with the foregoing considerations in mind, a complete skeleton organisation was laid out, as shown in the diagram on page 188. The first appointments to the various positions were made with the utmost care, and a continuous process of judicious selection and elimination was inaugurated, which, combined with the effect of daily training and experience, constantly tends to lift the force to a higher level of efficiency. An experience of three years of actual working has failed to indicate any point in which the general plan of organisation could be changed to advantage.

In a power plant whose load curve presents no great variation (*i. e.*, whose output throughout the twenty-four hours is substantially uniform), and which, therefore, requires the same number of operatives at all times, there are only two practicable schemes of organisation for the operating force. It may be divided into two twelve-hour shifts, or into three eight-hour shifts. The latter plan has advantages over the former in every respect save that of cost. Its adoption in the present case was made practically obligatory by two considerations:—

1.—The importance of the service demands that every employee on duty shall be always on the alert to detect conditions that might result in accident, and that he shall be at all times in condition to make the best use of all his faculties to meet any emergency that may arise. Under the heavy and nerve-



THIS MAP IS REPRINTED FROM AN ARTICLE ON NIAGARA FALLS POWER APPLICATIONS IN "CASSIER'S MAGAZINE" FOR MAY, 1901, BY PERMISSION OF H. W. BUCK



IN THE WHEEL PIT. OBSERVING THE TEMPERATURE OF A GUIDE BEARING ON ONE OF THE MAIN SHAFTS

trying responsibilities attaching to some of the positions men cannot be expected to keep available for a prolonged period the requisite mental and nervous energy for more than eight hours daily.

2.—The special knowledge and ability required for the proper performance of the duties of each position can be acquired only by actual experience in that position. The eight-hour plan is the only economical one whereby, in case of the temporary absence or sudden removal of an employee, his place can be filled immediately by an experienced hand. This is done by allowing each of the two other men in the same position to work twelve hours daily until the absentee returns or until a new man can be broken in.

The watches of the respective shifts

begin at midnight, 8 o'clock A. M., and 4 o'clock P. M. The shifts rotate each week on Saturday, when the men relieved at 8 o'clock A. M. report again for duty at 4 o'clock P. M., and the men relieved at 4 o'clock report again at midnight. The third shift is thus relieved from duty from midnight Friday until 8 o'clock A. M. on Sunday. Each man, therefore, once every third week has thirty-two consecutive hours off duty to compensate him for working two eight-hour watches (with eight hours rest between them) on each of the two intervening Saturdays. Reference to the diagram on page 188 shows that each shift of the operating force consists of fourteen men in the power station and one in each of the three outside local sub-stations.

At the head of each shift is the electrician-in-charge, who has entire charge of the plant and is directly responsible to the superintendent during his eight-hour watch, (1) for the successful operation of the plant; (2) for its maintenance and cleanliness; (3) for the conduct of the men; and (4) for the delivery of the plant in the best possible condition to his successor at the end of his watch. His specific duty is the operation of the two main switchboards, and his post, the captain's bridge of the plant, is Switchboard No. 1, although he usually directs in person all important switching on Switchboard No. 2.

The switchboards are the main nerve centres of the plant from which its various functions are directed and controlled. To each of them is brought the entire output of five generators, and from each of them are distributed into varied channels of usefulness 25,000 H. P. in electrical energy. Upon them are located instruments and appliances by means of which the attendant is always informed as to the output and voltage of the various generators and which indicate instantly the nature, and, within certain limits, the location

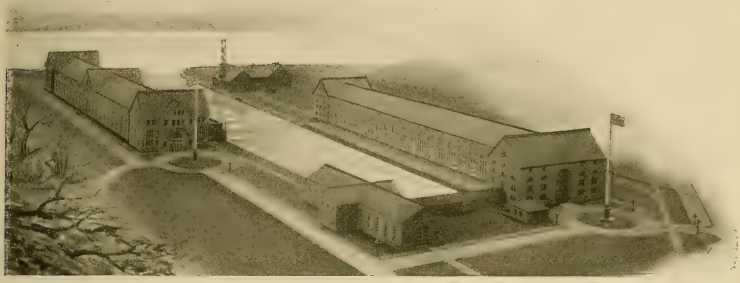
BI-WEEKLY INSPECTION. REMOVING SMALL STONES AND OTHER OBSTRUCTIONS FROM THE PORTS OF ONE OF THE TURBINES

THE FALLS AT NIAGARA

of any disturbance in any part of the system, whether in an alternator a few feet away, or in an underground cable in Buffalo, thirty-two miles distant. In front of the attendant are half a hundred levers controlling pneumatically the great dynamo and feeder switches and auxiliary switches by means of which any desired combination of alternators, feeders, and auxiliary circuits can be made. Here, by a crook of the finger, the attendant can, at will, cut off instantly the entire supply of power or any portion of it.

The successful occupant of the position of electrician-in-charge must possess an unusual combination of qualities. To a considerable theoretical knowledge and ripe experience must be added sound judgment, nerve that cannot be shaken by the most trying emergency, the ability to form quick, accurate judgments, and the decision of character and courage often required to act instantly on judgments thus formed. A keen sense of the responsibilities resting on him, and the constant consciousness of the disastrous results that may follow the slightest mistake on his part, must interfere in no wise with prompt and fearless action when required. He must possess a thorough and minute knowledge of the entire plant, from the point where the water enters the inlet canal to the transforming apparatus in the most distant sub-station. He must study carefully the various emergencies that may arise, and since in many of these emergencies instantaneous action is imperative, he not only must predetermine his line of action, but must mentally rehearse it so thoroughly that the time required for forming judgments and arriving at decisions will be eliminated, and the arrival of the emergency will produce automatically the proper action on his part.

One of the assistant electricians is stationed at Switchboard No. 2, where his routine duties, like those of the electrician-in-charge, are mainly to take and inscribe in books provided for the purpose half-hourly readings of the various indicating instruments upon his switchboard. Ordinarily his responsibilities are limited to the faithful and accurate carrying out of general and special instructions issued to him by the superintendent or the electrician-in-charge. Since all switching on No. 2 switchboard is usually done by the electrician-in-charge, or under his personal supervision, the attendant at No. 2 board, except in unusual emergencies, has little opportunity to act on his own initiative. While the position apparently demands no very high order of ability, it is important as a school for the development and training of candidates for the position of electrician-in-charge, and the performance of the men at this post, under circumstances affording any opportunity for the display of special qualifications, is carefully



BIRD'S-EYE VIEW OF THE POWER PLANT AS IT WILL APPEAR AFTER COMPLETION OF POWER HOUSE NO. 2

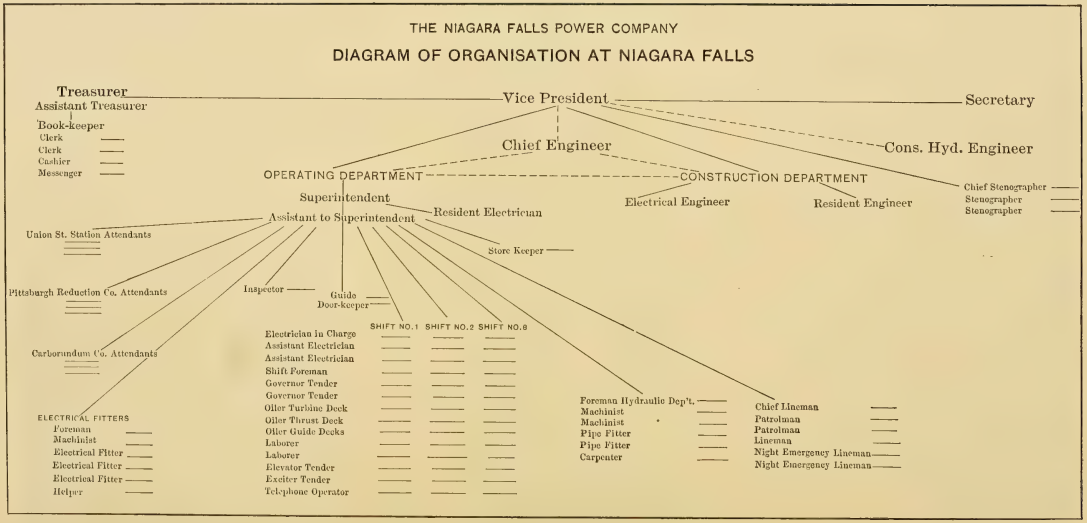


DIAGRAM OF THE LOCAL ORGANISATION OF THE NIAGARA FALLS POWER COMPANY IN OCTOBER, 1901. THE DOTTED LINES INDICATE CONSULTING RELATIONS

noted. The other assistant electrician is responsible for the cleanliness and good order of the alternators, the main and auxiliary switchboards and other electrical apparatus in the power house. He also has charge of the local substation known as the Street Railway Plant, which is located in the north end of the main power house, and consists of three 375 KW, 550-volt converters with their transformers and auxiliary apparatus supplying power to the local trolley lines. He inspects periodically

REMOVING EEL GRASS FROM THE INLET RACKS AT THE POWER HOUSE

the apparatus in the step-up transformer plant to see that the motor-driven blowers supplying the air-blast transformers are working properly, and to adjust the water supply to the oil-insulated, water-cooled transformers. He also attends to all switching in the step-up transformer plant by means of which rearrangements are made when required in the connections of the long-distance transmission circuits and the step-up transformers supplying them. These changes are made by means of 22,000-volt switches, and the work, for which specific instructions are issued in each case by the electrician-in-charge, demands the utmost care and precision in its execution. Both of the assistant electricians report directly to the electrician-in-charge.

The shift foreman is responsible to the electrician-in-charge for the operation of the entire motive power plant, from the point where the water enters the inlets up to and including the bearings in the main generators. He is stationed on the power house floor, and gives his personal attention to the governors and the alternator bearings in which work he is assisted by two helpers on the power house floor. Under his immediate supervision are the oilers, elevator tender, and labourers. The position is one of no small responsibility, and demands considerable knowledge of machinery, a thorough acquaintance with the plant, and experience in its operation. The success of the electrician-in-charge in operating the plant is largely dependent on the effective co-operation and efficiency of the shift foreman.

The three oilers are located in the

PREPARING FOR SUBMARINE REPAIRS TO THE INLET RACKS

wheelpit. One of them is stationed on the lowest, or turbine, deck, where he sees that the turbine bearings are continuously supplied with oil, and looks after the oil-filtering and pumping plant, by means of which the oil, after it has passed through the bearings, is purified and returned to the reservoirs under the roof of the power house, whence it again passes to the bearings under gravity pressure. He also has charge of the two air compressors which supply air for the operation of the pneumatic switches and for other purposes. The second oiler is located on the first deck below the power house floor, known as the thrust deck. He looks after all the thrust bearings located on this deck and the governor-driving mechanism immediately beneath the power house floor. To the third oiler is entrusted the care of the main guide bearings, of which there are two on each main shaft, and the numerous guide bearings of the four small exciter shafts. Every main bearing is examined at least once each half hour, when its temperature is taken and transmitted to the shift foreman, who records it in a book kept for the purpose, and is thus continuously informed as to the performance of each bearing.

The elevator tender has charge of the hydraulic elevator at the middle of the power house, which affords quick communication between the power house floor and every part of the wheelpit. At the north end of the wheelpit is an electric elevator held in reserve for use in case the hydraulic elevator should be, for any reason, temporarily out of service.

The primary duties of the labourers are the removal of eel grass, ice, and other drift material from the inlet racks. When their attention at this point is not needed they are employed in general cleaning about the plant. During the winter months, at times when the river is filled with anchor ice, it is necessary to remove temporarily many sections of the inlet rack to allow the an-

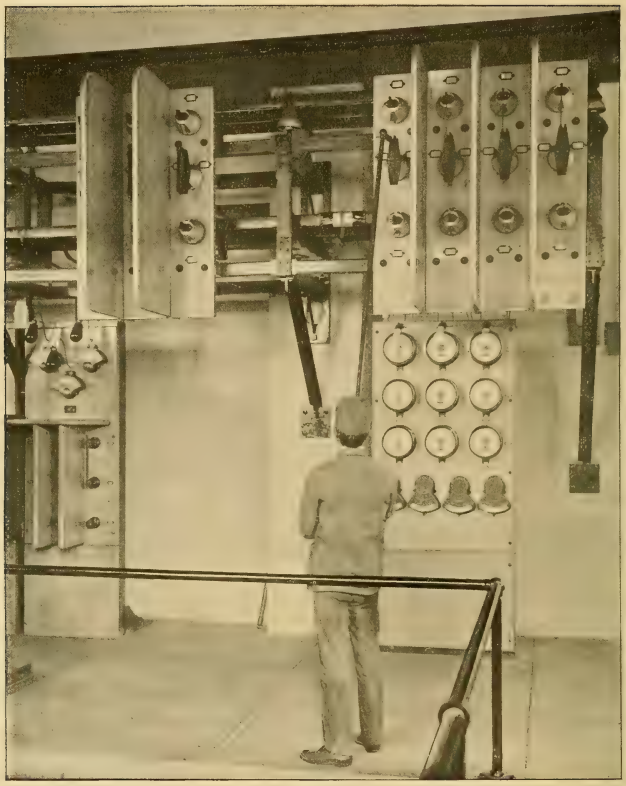
chor ice to pass through. A steam-driven locomotive crane is utilised to aid in this operation which must be performed with great rapidity. For this work, and to remove the heavy drift ice which sometimes accumulates in the forebay, an extra force of labourers is required. At night this force is in charge of a special foreman who is responsible to the shift foreman for keeping the water at the proper level in the inlets. During the daylight hours, when the regular maintenance crews are on duty and can be called on for emergency work of this character, the foreman of the hydraulic department can conveniently look after it. It involves, attendant regulates the speed of the several exciters as directed by the switchboard attendants.

The telephone operator has charge of the private branch telephone exchange located in the office building, whence he has direct communication with the main switchboards, all the local sub-stations, the transformer stations of the various power tenants, the several offices of the power company, and, through a private telephone line, with all the long-distance sub-stations in Buffalo, Tonawanda, and Lockport. The last-mentioned stations can also be reached by a special telephone line strung on the poles of the overhead

REMOVING A SECTION OF THE INLET RACKS BY MEANS OF A LOCOMOTIVE CRANE TO ALLOW ANCHOR ICE TO PASS THROUGH

at times, keeping an open channel several hundred feet long through the solid ice which forms in the river at the head of the canal.

The exciter attendant is stationed on the power house floor and has charge of the four 125-KW exciter dynamos located in the vicinity of the hydraulic elevator, each being driven by its own turbine through a vertical shaft. The transmission line. The position of telephone operator is one of considerable responsibility, and requires intelligence, quickness, accuracy in the transmission of messages, and close attention to duty. At times of emergency, when concerted action is necessary between the power house and several sub-stations, much depends on the efficiency and reliability of the attendant at this post. During



CONNECTING NO. 2 TRANSMISSION LINE WITH THE HIGH-POTENTIAL BUS BARS BY MEANS OF THE 22,000-VOLT SELECTOR SWITCHES IN THE STEP-UP TRANSFORMER PLANT

the night watches the operator uses his spare time in making up from the records of the switchboard attendants and the shift foremen a summary report of the operation of the plant for the preceding day. This report shows, at a glance, the maximum, minimum, and average output of each generator, corresponding data in regard to the gate opening of each turbine, the available head of water, the temperature of the various bearings, the potential at each set of bus-bars, the total output of the plant, and also the total number of kilowatt-hours delivered to each feeder. By comparing the last-mentioned figures with those obtained from the switchboard readings, a useful check on the accuracy of the meters is obtained. A continued discrepancy of more than one per cent. results in a recalibration of all of the dynamo and feeder watt-meters.

The guide and doorkeeper are on duty between the hours of 9 A. M. and 5.30 P. M. on week days, and from 10 A. M. to 4 P. M. on Sundays for the accommodation of the numerous visitors who desire to inspect the plant. The public interest in the power house is so

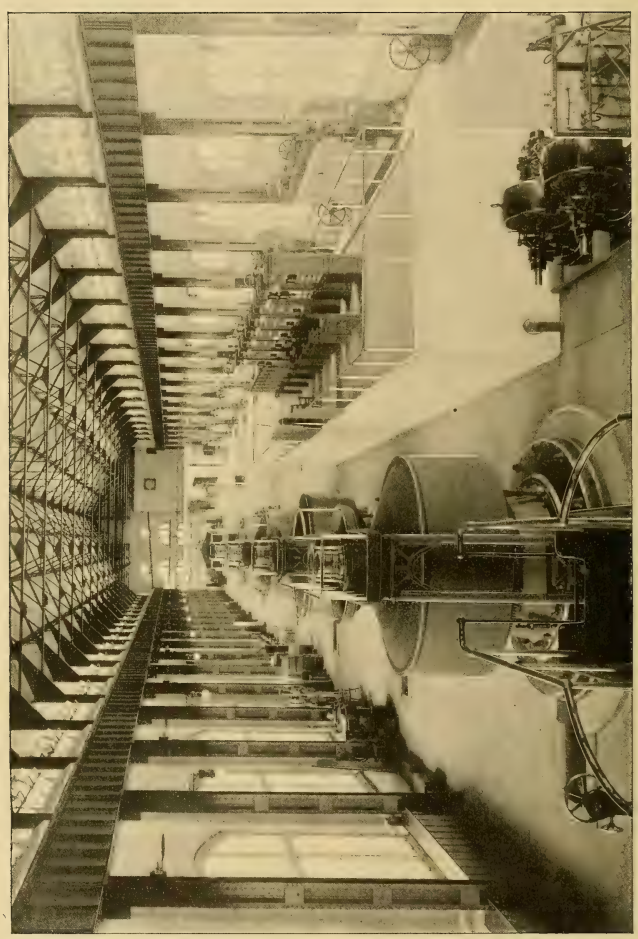
great that it was found necessary to appoint a guide in order to relieve the officers and employees of the company from constant demands on their time in conducting interested visitors through the establishment. In order to defray the cost of the guide and to keep the number of visitors within reasonable limits, a small admission fee is charged. The net proceeds of the fund thus created are devoted to the endowment of beds in the Niagara Falls Memorial Hospital for the benefit of employees of the company who may be disabled by sickness or accident.

To carry on work of maintenance and repair which cannot be performed by the regular operating force without neglect of proper attention to the running of the plant, a maintenance force was established. This force ordinarily works ten hours daily, but in case of emergency it is expected to remain on duty as long as circumstances may require. If urgent repairs, requiring several days for completion, are in hand, the force is augmented, if necessary, and is divided into relays so that the work may proceed continuously. The maintenance force is divided into three general groups, though the men are sometimes shifted from one group to another as may be found expedient to facilitate the execution of work in progress.

The foreman of the hydraulic department, assisted by two machinists, a carpenter, and two pipe-fitters, attends to the maintenance and repair of the machinery comprising the hydraulic or motive power plant and the buildings in which the main power plant and substations are housed. This force, with occasional extra help, has proved itself capable of handling all work required to maintain the plant in good condition and to repair damage caused by accidents, besides accomplishing a large amount of work in making the minor alterations and improvements which are constantly suggested by experience in the operation of such a plant.

The group of electrical fitters comprises a foreman, a skilled machinist and instrument maker, and three or more electrical fitters. A wide variety of work falls to the share of this group, which looks after all the electrical apparatus in the main power plant and the local sub-stations, and also the underground cables transmitting power to the local tenants. It is liable to be called on to undertake, at a moment's notice, any kind of electrical work, from the

STORE HOUSE AND LINEMEN'S HEADQUARTERS IN NORTH TONAWANDA



A RECENT INTERIOR VIEW OF POWER HOUSE NO. 1. THE EQUIPMENT COMPRISES TEN ELECTRIC GENERATORS, EACH OF 5000 HORSE-POWER.

SWITCHBOARD NO. 1. ELECTRICIAN IN CHARGE TAKING READINGS OF THE INSTRUMENTS

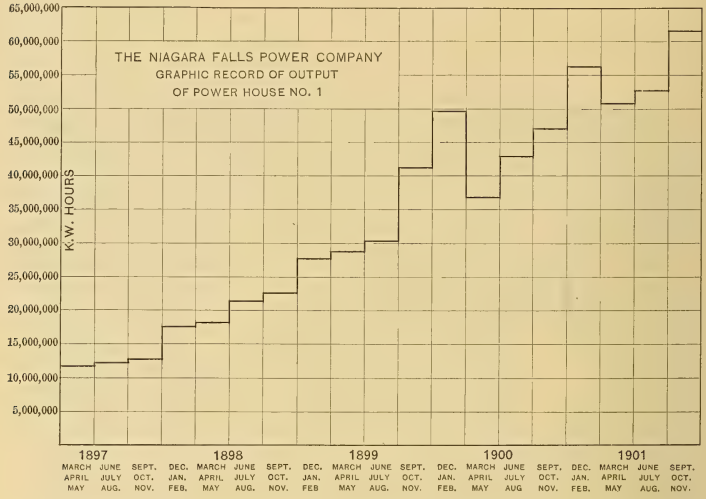


DIAGRAM SHOWING THE OUTPUT OF THE PLANT IN KILOWATT HOURS FOR EACH QUARTER SINCE MARCH, 1897

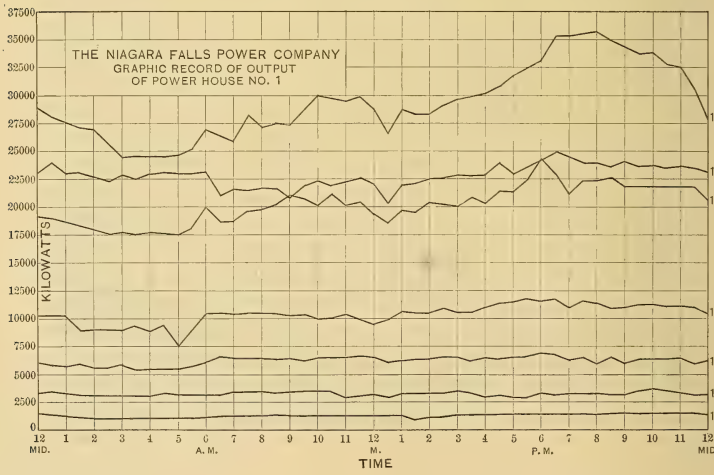
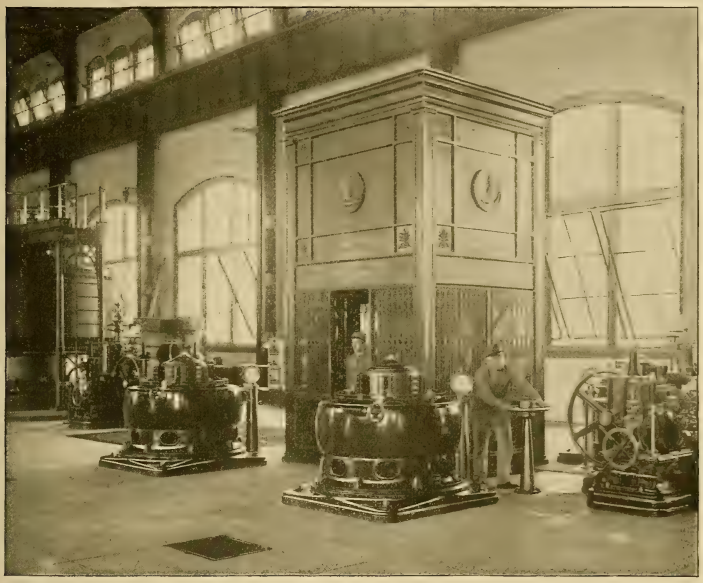


DIAGRAM SHOWING GROWTH OF OUTPUT BY MEANS OF A LOAD CURVE FOR THE SAME DAY (OCTOBER 18) IN EACH YEAR SINCE THE PLANT WAS INSTALLED

replacement of an armature winding on one of the main generators, or the reconstruction of a burnt-out transformer, to the building of a delicate measuring instrument.

In addition to ordinary repairs and a large amount of construction work in the installation and rearrangement of apparatus incident to the growth of the plant, it has performed in the building of special appliances and in the alteration of auxiliary apparatus much work of a kind that is usually undertaken only by well-equipped manufacturing establishments. Under the direction of the resident electrician, this force has also carried out many elaborate tests and a considerable amount of original experimental work resulting in useful additions to scientific knowledge and in the development of electrical appliances of practical value in the operation of the plant.



THE EXCITER PLANT AND ELEVATOR ENCLOSURE. GOVERNOR OF UNIT NO. 5 ON THE RIGHT

The long-distance distributing plant, by means of which power is delivered to Buffalo, the Tonawandas, and Lockport, consists of three tri-phase, 22,000-volt circuits carried on two separate pole lines, each approximately twenty-two miles long. In North Tonawanda, midway between the power house and the terminal house in which the current is reduced to a pressure of 11,000 volts for underground distribution in Buffalo, is a sub-station where the lines are tapped to supply the Tonawanda Power Company, and where a fifteen-mile branch transmission line, delivering power to Lockport tenants, is supplied with energy. The care of the overhead transmission lines is entrusted to a chief lineman living in North Tonawanda. His force consists of two patrolmen and an emergency lineman living in Tonawanda, an emergency lineman stationed at the main power house at night, and a night emergency lineman living at La Salle, about five

THE NIAGARA FALLS POWER CO.

SUMMARY OF DAILY REPORTS.

POWER HOUSE No. 1; SWITCHBOARD No. 1.

FOR 24 HOURS, ENDING 12 P. M. Friday, Oct 18, 1901

TURBINE REPORT

	MAXIMUM		MINIMUM		AVERAGE
	FEET	TIME	FEET	TIME	FEET
Head of Water	134.50	4 A. M.	133.65	5:30 P.M.	134.32
	MAXIMUM		MINIMUM		AVERAGE
	PER CENT. OF FULL GATE	TIME	PER CENT. OF FULL GATE	TIME	PER CENT. OF FULL GATE
Turbine No. 1. Gate Opening	79	8 P.M.	54	4 A.M.	52
Turbine No. 2. Gate Opening	76	7 P.M.	52	7 A.M.	62
Turbine No. 3. Gate Opening	75	7:30 P.M.	52	7 A.M.	60
Turbine No. 4. Gate Opening	92	5:30 P.M.	61	12:30 A.M.	73
Turbine No. 5. Gate Opening	75	7 P.M.	50	7 A.M.	62

DYNAMO REPORT

	MAXIMUM		MINIMUM		AVERAGE
	VOLTS	TIME	VOLTS	TIME	VOLTS
No. 1 Bus Bars. Potential, Phase A.	2500	6 P.M.	2400	12 Mid.	2425
No. 1 Bus Bars. Potential, Phase B.	2500	6 P.M.	2400	12 Mid.	2425
No. 2 Bus Bars. Potential, Phase A.	2320	12 Mid.	2320	12 Mid.	2320
No. 2 Bus Bars. Potential, Phase B.	2320	12 Mid.	2320	12 Mid.	2320
	MAXIMUM		MINIMUM		AVERAGE
	K. W.	TIME	K. W.	TIME	K. W.
Dynamo No. 1. Output	3680	5:30 P.M.	1920	7 A.M.	2764
Dynamo No. 2. Output	3500	7 P.M.	1950	5 A.M.	2615
Dynamo No. 3. Output	3400	7:30 P.M.	1930	7 A.M.	2579
Dynamo No. 4. Output	4300	5:30 P.M.	2700	12 Mid.	3295
Dynamo No. 5. Output	3400	5:30 P.M.	2000	7 A.M.	2000
Total	17500	5:30 P.M.	9080	4:30 A.M.	13253

FEEDER REPORT

Number of Feeder	1	2	3	4	5	TOTAL
Kilowatt Hours	46000	50000	53000	54000	53000	256000
Kilowatt Days (24 Hours)						12066

REMARKS:

Grand Total Dynamo Wattmeters 29138

" " Feeder " 29656

COMPILED FROM DAILY REPORTS. APPROVED

BY _____ _____

FAC-SIMILE OF A TYPICAL DAILY REPORT, GIVING A RESUMÉ OF THE OPERATION OF THE PLANT FOR OCTOBER 18, 1901

miles from the power house. The lines are inspected daily by the two patrolmen, each taking half of the line, while the emergency man at Tonawanda remains on duty at the Tonawanda station. In case of trouble on the line at night, two men start from Tonawanda,—one towards Buffalo, the other towards the power house. A man is sent from the terminal house at Buffalo to meet the man from Tonawanda, and the emergency lineman at La Salle follows the line until he meets the other man from Tonawanda. The lineman from the power house proceeds along the line to La Salle and reports from there. In this way the entire line can be covered in a very short time. Reports from the men are received by means of telephones located in patrol boxes at various points along the line.

An emergency waggon, with a complete equipment of all the appliances and material required for every kind of

THE NIAGARA FALLS POWER CO.

SUMMARY OF DAILY REPORTS.

POWER HOUSE No. 1; SWITCHBOARD No. 2.

FOR 24 HOURS, ENDING 12 P. M. Friday, Oct. 18, 1901

TURBINE REPORT

	MAXIMUM		MINIMUM		AVERAGE
	FEET	TIME	FEET	TIME	FEET
Head of Water					
	MAXIMUM		MINIMUM		AVERAGE
	PER CENT. OF FULL GATE	TIME	PER CENT. OF FULL GATE	TIME	PER CENT. OF FULL GATE
Turbine No. 6. Gate Opening	96	11:30 P.M.	60	8:30 A.M.	80
Turbine No. 7. Gate Opening	89	8:30 P.M.	72	1 A.M.	77
Turbine No. 8. Gate Opening	94	1:30 P.M.	73	1 A.M.	81
Turbine No. 9. Gate Opening	98	6:30 P.M.	74	8 A.M.	85
Turbine No. 10. Gate Opening	98	6:30 P.M.	75	3:30 A.M.	85

DYNAMO REPORT

	MAXIMUM		MINIMUM		AVERAGE
	VOLTS	TIME	VOLTS	TIME	VOLTS
No. 3 Bus Bars. Potential, Phase A.					
No. 3 Bus Bars. Potential, Phase B.					
No. 4 Bus Bars. Potential, Phase A.	2320	12 Mid.	2320	12 Mid.	2320
No. 4 Bus Bars. Potential, Phase B.	2320	12 Mid.	2320	12 Mid.	2320
	MAXIMUM		MINIMUM		AVERAGE
	K. W.	TIME	K. W.	TIME	K. W.
Dynamo No. 6 Output	4060	11:30 A.M.	2480	8 A.M.	3522
Dynamo No. 7 Output	3880	8:30 P.M.	3180	3:30 A.M.	2164
Dynamo No. 8 Output	4260	10 A.M.	3100	1 A.M.	3780
Dynamo No. 9 Output	3860	4:30 P.M.	1840	6 A.M.	3391
Dynamo No. 10 Output	3840	1:30 P.M.	2860	3:30 A.M.	3328
Total	16980	8 P.M.	11680	12:30 P.M.	16185

FEEDER REPORT

Number of Feeder	6	7	8	9	10	11	12	13	TOTAL
Kilowatt Hours	54000	89000	56000	105000	107000	7000	30000	8000	456000
Kilowatt Days									19000

REMARKS:

Grand Total Dynamo Wattmeters 29438

" " Feeder " 29666

COMPILED FROM DAILY REPORTS APPROVED

BY

FAC-SIMILE OF A CORRESPONDING REPORT BLANK, FILLED OUT, FOR SWITCHBOARD NO. 2 FOR THE SAME DAY

line repair, is stationed at Niagara Falls, in a stable whose proprietor is under contract to have the waggon horsed and delivered at the power house, ready for a quick trip to any part of the line, at any hour of the night or day, within fifteen minutes after receipt of notice. Another waggon, similarly equipped, is stationed at Tonawanda under the same arrangement.

The night emergency lineman at the power house has been ordered out for the purpose for which he was appointed only once in more than two years of service, and in order to keep him occupied he is made responsible for the cleanliness of the step-up transformer plant and the cable subways in the power house. The emergency lineman at La Salle has also had a sinecure so far as night work is concerned, but is employed by day as one of the electric fitters. The maintenance of a line of this character demands constant watch-

UNFINISHED SECTION HOUSE ADJOINING THE TONAWANDA SUB-STATION. IT WILL CONTAIN SWITCHES BY MEANS OF WHICH ANY CONDUCTOR OF THE TRANSMISSION LINES MAY BE DIVIDED, TO FACILITATE LOCATION OF A DEFECT

fulness, and the sometimes dangerous work of remedying defects requires intelligence, nerve, and good judgment.

A record of more than thirteen consecutive months without interruption of service due to line troubles, in a region infested with mischievous, kite-flying, stone-throwing boys, and hunters, to whom an insulator is a shining mark, is the best evidence of the care and vigilance with which the work has been performed. Among the tasks which the line force has been called upon to perform are the replacement of a broken insulator on a "live line," and the removal and replacement of a pole on the line while in service. Both of these feats were repeatedly performed with conductors charged to a potential of 11,000 volts, and each of them has recently been accomplished without accident or interruption of service with lines in operation at 22,000 volts.

In connection with the organisation of the operating force the questions of storeroom administration and keeping account of operating expenses were given much attention. These questions, while not directly connected with the organisation of a force of operatives, are, nevertheless, important factors in the administration of the operating de-

partment, and have a vital bearing on the successful accomplishment of the purposes for which the operating force was established.

For the successful operation of the plant and the prompt execution of repairs it is necessary to have constantly available not only an ample supply of materials used in routine operation, but also a complete assortment of spare parts of apparatus from which quick replacements or renewals can be made when required. In order to keep the storeroom properly stocked, an accurate list of its contents must be available at all times, and means must be provided to insure the replenishment of the supply of a needed article before the stock has become exhausted. To accomplish these objects, the well-known card system of stock ledger was adopted. Under this system each article carried in the storeroom has a card showing the amount purchased and from whom, the

STOCK RECORD OF ... Where kept ... Max. ... Min. ...

DATE	ORDERED				PRICE			RECEIVED		DELIVERED		BALANCE	VALUE OF GOODS RECEIVED	VALUE OF GOODS DELIVERED
	Order number	Date of order Mo. Da. Yr.	Quantity	Per	List	Disc.	Net	Quantity	From	Quantity	To			

FAC-SIMILE OF ONE OF THE STORE ROOM CARDS ON WHICH THE STOCK LEDGER IS KEPT

price, the amount issued from the storeroom from time to time, to whom it was issued, to what account it is chargeable, and the amount remaining in stock. The maximum and minimum quantities of the article to be kept in stock are indicated on the card, and when the balance shown approaches the minimum, the storekeeper must make requisition for additional supplies. A complete set of forms was developed for making requisitions, orders for material, and reports, which has proved extremely satisfactory, and by means of this any desired information as to the condition of material in the storeroom and goods on order from the manufacturers can be readily obtained.

The economical operation of any power plant requires that its accounts shall be so kept that the cost of any department for a given period can be readily ascertained, in order that comparisons may be made that will call attention to undue expenditures and thus lead to their elimination. For the purposes of cost keeping, general ledger accounts were established by the treasurer's department, as here given:—

Motive Power Plant.
Electric Generating Plant.
Local Distributing Plant (Cables, Conduits and Meters).
Long-Distance Distributing Plant.
Step-up Transformer Plant.
Railway Plant.
Pittsburg Reduction Co. Plant.
Pittsburg Reduction Co. Transformer House.
Carborundum Company Plant.
Carborundum Company Transformer House.
Union Street Transformer Plant.
Union Street Transformer House.
Laboratory and Testing Apparatus.
Power House and Office Buildings.
Telephone Line on Transmission Pole Line.
Private Telephone Line to Sub-stations—Rental.
Telephone Connection to City Exchange—Rental and Tolls.
Machine Shop.
General Expenses.
Sewers and Roadways.
Docks.
Sidewalks.
Lawns and Grounds.
Farm Buildings.
Farm Lands.
Taxes.
Insurance.

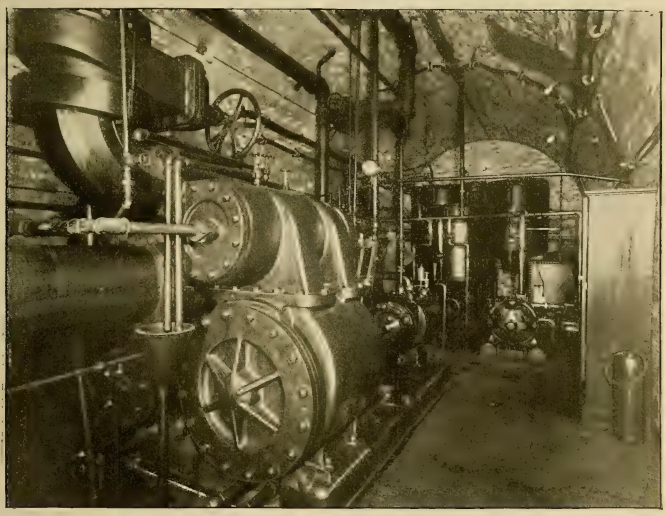
Each of these general accounts was again divided into the following sub-accounts, or as many of them as were applicable:—

AN EPISODE IN FEBRUARY, 1899. THE TRAVELLING HAND DERRICKS HAVE SINCE BEEN REPLACED BY THE STEAM-DRIVEN LOCOMOTIVE CRANE SHOWN ON PAGE 191

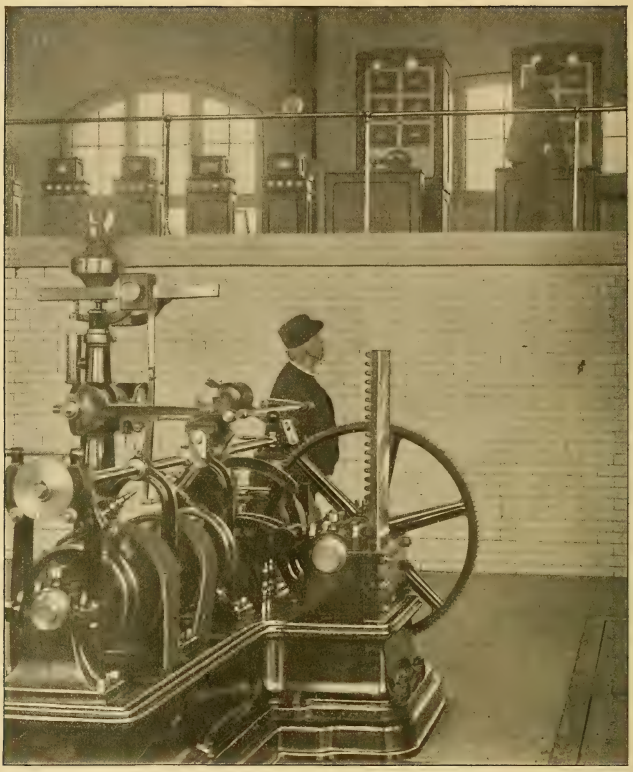
Operation—Labour.
Operation—Material.
Maintenance—Labour.
Maintenance—Material.
Maintenance—Contracted for.
Repairs—Labour.
Repairs—Material.
Repairs—Made Under Contract.
Inspection and Testing.
Oil for Lubrication.
Lighting—Incandescent.
Lighting—Arc.
Improvements and Betterments.

All items of cost, whether for labour or material, are thus readily distributed, each into its own proper account. A book containing a complete list of all the accounts is kept in which the expenditures for each month are brought together in parallel columns, so that the cost of any department for a given month can be compared with the cost for the corresponding month of any other year, or with the cost for any other month. These comparisons are of the greatest assistance in the economical administration of the operating department, and the system of accounts furnishes, in minute detail, ready information as to the cost of operation, maintenance, or repair of any department or of the plant as a whole.

To what extent has the organisation herein described accomplished the objects aimed at in its creation? It is obvious that the efficiency of the organisation and that of its personnel must be judged by the record of the operating plant for the period of nearly three years which has elapsed since the organisation was established. During this time the supply of power has suffered total interruption on only one occasion, when a temporary failure of the water supply, caused by an ice jam in the river, necessitated an eighteen-minute shutdown. During the year 1900 general interruptions of service to the local power tenants amounted to only thirty-seven minutes in the aggregate. Between November 7, 1900, and October 25, 1901, there were only two general interruptions of the local service, aggregating thirty minutes in duration. The long-distance service, depending, as it does, on a system of overhead lines exposed to lightning and the wanton interference of mischief-makers, delivering power to an extensive instal-



OIL PUMPING AND FILTERING PLANT AND WATER-DRIVEN AIR COMPRESSOR LOCATED IN CHAMBER ADJOINING THE TURBINE DECK, 150 FEET BELOW THE POWER HOUSE FLOOR



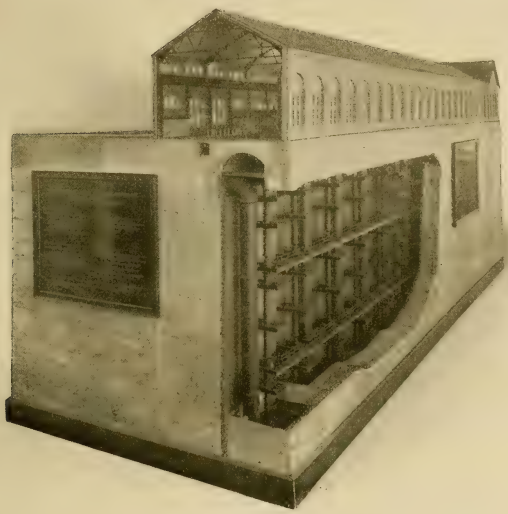
SYNCHRONISING A 5000 HORSE-POWER ALTERNATOR. THE GOVERNOR ATTENDANT ADJUSTS THE SPEED, AS SHOWN BY AN INDICATOR AT THE EXTREME RIGHT, NOT SEEN IN THE ENGRAVING, UNTIL THE MACHINE IS "IN STEP." THEN THE SWITCHBOARD ATTENDANT CLOSES THE SWITCH, PARALLELLING THE MACHINE WITH THE OTHERS

lation of underground cables working under very high voltages, has necessarily been subjected to occasional interruptions, which, however, have rarely exceeded five minutes in duration. As stated by Mr. L. B. Stillwell, in a paper on the Niagara plant recently read before the American Institute of Electrical Engineers, "of the various troubles that have occurred in operation, those due to mistakes or lack of vigilance constitute a proportion quite insignificant."

In the opinion of the writer, the record warrants the conclusion that the first object of the organisation has been as nearly attained as has been possible under the conditions imposed. Each department of the maintenance force has earned for itself a well-established reputation for thorough, conscientious, energetic work. The present condition of the plant and the fact that on more than one occasion anticipated complaints from tenants on account of temporary partial suspension of power service have been turned into expressions of gratified surprise at the celerity

with which required repairs have been made, testify to the thorough accomplishment of the second and third aims of the organisation.

In respect to the fourth object, which relates to annual cost,* experience has shown that the operating force is not larger than is required to handle effectively the emergencies that sometimes arise. The maintenance force for the care of the hydraulic plant and the electrical plant is somewhat larger than is necessary for the execution of ordinary repairs, but since the spare time of this force is always profitably utilised in construction work, the surplus labour does not add to the maintenance charges, yet is always available for cases of emergency. The employment of patrolmen for the daily minute inspection of the long-distance transmission lines, and of emergency linemen, is amply justified by the importance of the service and the consequent necessity for prevention of accidents and for the prompt location and repair of any defect that may develop in any part of the system. The broad-minded policy that has been consistently adhered to demands that no reasonable outlay tending to secure continuity of service shall be withheld, and in view of this policy the force employed, while ample for the purpose, is not larger than is required for the complete attainment of the aims of the organisation.



WORKING MODEL OF POWER HOUSE NO. 1, SHOWN AT THE PAN-AMERICAN EXHIBITION AT BUFFALO

The broad view taken in the adoption of liberal factors of safety in the working of the organisation has been made possible by the gentlemen composing the board of directors of the company, to whose provision of ample means for its creation and maintenance the success of the organisation is largely due.

*While detailed figures as to expenses cannot be given here, it may be noted, as a matter of general interest, that for the two years ended June 30, 1901, the entire cost of maintenance and repair of the electric generating plant, including alternators, exciters, and switchboard apparatus, has approximated one per cent. per annum of the original cost. The motive power plant, including turbines, shafts, governors, inlet racks, etc., has cost for maintenance and repairs less than two per cent. per annum on the investment. In each case, these percentages include certain items for alterations and additions which might reasonably be charged to "Improvements and Betterments" or to construction account.

A SMOKELESS LONDON

THE PROMISES OF GASEOUS FUEL AND ELECTRICITY

By W. C. Popplewell

IT is now rather more than 600 years since the first law was passed which was directed against what we so well know at the present day as the smoke nuisance. The earliest record which we have of notice being taken of the evils caused by the emission of black smoke into the atmosphere of London seems to be roughly coincident with the discovery of coal in the north of England, followed by its importation into the capital and its use there. The origin of the first proclamation issued for the suppression of the smoke nuisance is interesting and extremely quaint. The facts appear to be these:—The coal smoke apparently caused no immediate annoyance to the inhabitants of London themselves, but to the parliamentary representatives from the country districts, and it was for the protection of these "knights of the shire" that, we are told, what was, in effect, the first smoke Act passed, about the time of Edward the First, in order that they might not suffer injury to their bodily health while attending to their duties during the sittings of Parliament. Even in those days it was only when the members of Parliament themselves began to feel the effects of the smoke that steps were taken to mitigate the nuisance, a result to which it is not difficult to find many analogies at the present day.

From that time to the present many attempts, some of them successful, others failures, have been made to bring the law to bear on those people who cause a harmful amount of black smoke to be sent out into the air in the neighbourhood of their fires. After the proclamation of Edward no further action that we have any record of was taken until the time of Elizabeth. This also took the form of a proclamation, and was again promulgated in order to protect the members of Parliament from the ravages of London smoke.

During the reign of Charles the Second, however, we hear that for the first time the inhabitants of London themselves presented a petition to Parliament, in which it was stated that they wished to put a stop to, or to limit, the importation of coal from Newcastle, on account of the injurious effects which were being wrought on the inhabitants by the presence of the smoke given out by the "sea coal," as it was called at that time. From those early times to the present day the subject has been spasmodically attacked, but the growth of the evil has been so rapid as to quite outstrip any progress in the attempts at its amelioration; and now it would seem an almost hopeless task to try and put in order the house that has for so long a period been allowed to remain in a state of dirtiness and which has grown worse year by year. But there are possible ways of abating, if not entirely curing, the evil, and these it is the writer's present purpose to discuss.

First, as to the causes and extent of the smoke evil, it may be said that almost the whole of the smoke which is sent into the atmosphere is from the combustion of coal; the amount arising from the combustion of fuels other than

coal is so small in comparison as to be practically negligible.

Coal is burnt for two distinct purposes, namely, industrial and domestic; and it is not easy to estimate the extent to which each of these is responsible for the contamination of the atmosphere. From these two sources there are said to be over fifty tons of carbon always in suspension in the atmosphere immediately above London. This all comes from coal imperfectly consumed. If coal were burnt in such a way that perfect combustion could be effected, no smoke would be produced, and nothing beyond carbonic acid gas, some sulphur dioxide, and infinitesimal quantities of some other minor products of combustion, all of which are invisible, though not entirely innocuous, would be sent into the atmosphere. The combustion of coal, in whatever kind of furnace used, is analagous to the burning of oil in an ordinary lamp. Here, if the quantity of oil supplied is too great and the air supply limited, the flame smokes unpleasantly; on the other hand, when the oil supply is small and the air abundant, no smoke will be made, but an excess of air will have been admitted, and too much heat will have been carried away, up the lamp chimney, combustion again being unsatisfactory by reason of having not too much, but too little, air.

What is true for the lamp is also true of the combustion of coal in commercial furnaces and domestic fireplaces. If the air supply is deficient smoke will be produced; on the other hand, a too liberal supply of air in most cases means freedom from smoke, but also a great waste of heat, as the excess air is heated and discharged uselessly up the chimney.

In the case of industrial furnaces, the main object to be attained is to so regulate the air supply that a minimum of smoke is given off, and, at the same time, the smallest possible quantity of heat is carried away in the waste gases and dissipated in the surrounding atmosphere. Experience shows that in well-constructed and properly handled furnaces it is possible in most cases burn coal without smoke, and, at the same time, to maintain a good economy in the heat generated during combustion. Engineers are agreed that manufacturers can, if they will, burn their coal smokelessly and economically. Unfortunately, in too many cases the desire to avoid smoke does not exist, and the well-being of the community is sacrificed in order that the first cost of suitable furnaces may be avoided. Little trouble is taken to see that the persons in charge of the furnaces do their work properly. It is often urged that manufacturers would benefit themselves by avoiding smoke on account of the unburnt fuel that would be thus saved; but this can hardly be taken seriously, because the percentage of solid matter sent into the air as smoke is so small as to be negligible. A furnace which burns without smoke at the expense of a large excess of air and consequent waste of heat is likely to be much more wasteful than one which makes a little smoke and uses but a small quantity of excess air.

The main object is to so control the air supply that the production of smoke is just avoided and nothing more. When this is the case the chimney will have the appearance that it ought to have, and the owner of the furnace will be getting the best value for the coal he burns.

With domestic fires the case is different. It seems to be almost a point of honour among English people to prefer to burn their domestic fuel in open fireplaces, and it will be a long time before the majority will be brought to consent to adopt the closed stoves used in other countries. For this we can hardly be blamed. Closed stoves, and systems of hot-water and hot-air pipes all transfer their heat to the surrounding air almost entirely by the process of convection, as opposed to radiation by which most of the heat sent out from an open coal fire reaches the parts of a room which are adjacent to it. Of course, in this case also it is by convection that the heat is ultimately distributed throughout the room.

Heating wholly by convection ap-

pears to have the effect of rendering the air unpleasantly dry and baked, and no system by which it can again be moistened has yet been devised which makes the air as healthy and comfortable as when heated in the ordinary way by radiation from open fires. There can be little doubt that the air in a room heated in this way is more healthy to breathe and pleasant to be in than one heated by one of the many other systems. An open fire, moreover, insures good ventilation of a room, and not the least important attraction is its cheerful appearance. Much of the prejudice which Englishmen have against closed stoves and systems of radiation is, no doubt, due to the many imperfections in the carrying out of these systems rather than to the main principles involved.

The combustion of coal on an open grate is well known to be a most wasteful manner of utilising the heat latent in the fuel, and is probably the most uneconomical way of deriving heat from a natural fuel of any kind. Moreover, the conditions are such that the process is a very smoky one. For smokeless combustion or for the minimum production of smoke it is not simply necessary that the air supply be adjusted in the manner previously described, but also that the supply of fuel and air be uniform. When fuel is supplied to a furnace of any kind in a perfectly uniform manner it is possible to adjust the air supply to a nicety, so that no smoke will be produced, and at the same time the minimum amount of air is used. These conditions are attained in the case of several forms of mechanical stokers for boilers, and in cases of the burning liquid or gaseous fuels; but in hand-fired industrial furnaces, and in open house-fires, the supply of fuel is intermittent, and the regulation of the air supply becomes more difficult, especially in the case of the open fires.

A boiler or other industrial furnace is so constructed that if the necessary amount of care is taken it is possible to adjust the air supply so as to maintain a smokeless chimney; but this adjustment must be made after each firing. In an open house-fire there is no possibility of providing for a proper regulation of the air supply, as the air has at all times free access to the fire and flows into the chimney in a more or less uniform stream, according to the state of the chimney draught. Not only is it impossible to properly control the air supply, but the fuel supply is intermittent as well, and the quality of the coal may vary greatly. At one time the fire may be incandescent, with a plentiful supply of air, and consequently burning without smoke. A few minutes later a shovelful of green coal may be heaped on the top of this incandescent fuel, lowering the temperature of the fire, and thus diminishing the chimney draught, with the result that the hydrocarbons are slowly driven off from the coal with the accompaniment of much black smoke.

No amount of additional air supply will put a stop to this smoke unless at the same time the temperature of the grate and the flue can be raised. It is the case of the lamp again. So long as an oil wick burns in the open air and is supplied with a superabundant supply of oil, the flame produced will be smoky, and this will not be cured until the oil supply is limited or the flame is supplied with a chimney, in which case the chimney draught is increased and the temperature raised by the more perfect combustion of the oil.

Very little improvement has been brought about in open grates during the past fifty years, though perhaps it is only fair to say that the one real advance which has been effected is to be found in the adoption of a high firebrick back to the grate, and in the use of a much reduced draught opening at the top of this back. In this way the back of the fire is kept at the high temperature conducive to more perfect combustion of the hydrocarbons, and, at the same time, the smaller chimney opening reduces the waste of heat, which would otherwise go up the chimney; in this way fuel is saved.

It has been estimated that the amount of solid carbon sent into the air as smoke is from 3 to 5 per cent. of the

fuel burnt in the case of open, domestic fires, and only about 0.5 to 0.75 per cent. in well-constructed and carefully fired boiler furnaces, which shows that, as a smoke producer, the individual boiler furnace is much behind its domestic brother. For each hundred pounds of coal burnt on domestic fireplaces, therefore, about four pounds are sent into the air as smoke, while for boiler furnaces the corresponding amount is considerably less than one pound. These figures are not the result of mere guesswork, but the amounts have been directly ascertained by collecting samples of different flue gases, separating out the smoke carbon, and weighing it. From this it is gathered that, as regards smoke production, the domestic fire is a far worse sinner than the much-abused industrial furnace; but the amount of coal burnt on a domestic fireplace in a day is exceedingly small as compared with the amount burnt on a boiler furnace in the same time, and the latter, by reason of its greater capacity, may thus contribute much more largely to the smoke nuisance than the more modest fireplace.

It is unnecessary to enter upon a long discussion of the evil results from a smoky atmosphere. Most of these are well known. There are, for example, the disfigurement of public and private buildings, the retardation and in many cases the total stoppage of the growth of shrubs and flowers, the production of dirty fogs, and the soiling of articles of wearing apparel. But the effects on the health of a community exposed to the contaminated atmosphere are of still more importance; for, besides the direct effect on the lungs and the general health of persons breathing the poisoned air in contributing to or accelerating the progress of lung diseases, there is the secondary effect by which housewives are led to keep their windows tightly closed, in order to preserve curtains and furniture. This leads to impure air within the houses, and again contributes to the spread of lung disease. Another way in which health may be interfered with,—and this is an effect often lost sight of—is to be found in the shutting out of sunshine, caused by the smoky pall which hangs over London on many days throughout the year.

It seems to be generally conceded that the formation of fogs of any kind, whether in town or country, is facilitated by, if not entirely dependent upon, the particles of dust which everywhere pervade the air. When the air is still and its temperature falls below a certain point, the watery vapour in it condenses and takes the form of minute water globules, which, in the aggregate, become what we so well know as a fog. The formation of these globules is largely assisted by the particles of dust in the air, each globule forming round a dust particle as a nucleus. In the purer atmosphere of the country the fog is not so readily formed as in a town atmosphere charged with numberless particles of solid matter, chiefly of carbon from coal smoke. Besides this, a country fog, when it does exist, is nothing more or less than a white mist, which may be in some ways unpleasant, but is not injurious to health, except in so far as it is moist and cold.

But a London fog is rendered much more dense than one in a country district because of the greater facility in its formation, and, in addition to this, it is far more injurious in its effects. Each globule is not merely a microscopic sphere of pure water, but is built round a particle of carbon which may possibly be non-injurious in itself, but may be accompanied by a quantity of sulphurous acid from the combustion of the coal. It is to the presence of the carbon and the sulphur in the fog that we must attribute its partially opaque and yellow appearance, and one has only to spend a few minutes in a thick London fog to be convinced of the presence of a large quantity of sulphur, the taste of which is unmistakable.

It is almost unnecessary to attempt to enumerate the many annoyances and worse evils which may be attributed to fogs. Everyone is familiar with the inconveniences caused by traffic of all kinds being interfered with, and by the complete stoppage, in some cases, of

any attempt to make progress on foot. To these must be added the cost of lighting buildings which have been darkened by the fog outside. But the worst evil of all, and one which alone ought to be sufficient to cause a most vigorous protest against so much black smoke in the atmosphere of London, is to be found in the previously mentioned disastrous effects of sulphurous fog on the lungs of all persons exposed to it, and especially to those who already have weak or diseased lungs. Some people are obliged, by reason of their callings, to remain exposed to a fog for hours, and in this way are compelled to breathe a large amount of air which is charged with the hurtful acids.

Such are, in brief, a few of the evils of the fogs with which London is visited many times every year, and although it would be saying too much to assert that by completely freeing the atmosphere of London from black smoke fogs would no longer trouble us, it is certain that such fogs would not occur so frequently, would be far less unpleasant to the general public, and, at the same time, would be far less injurious to the community. Where there is a smoke-laden atmosphere there must be thick, yellow fogs, and it is only by removing or lessening the smoke that any hope can be entertained of freeing London from these scourges.

On the desirability of cleansing the atmosphere of the metropolis from the contaminating effects of the smoke from house and factory fires there can only be one opinion. But the question arises, How far is it possible to purify the air of London? Still maintaining the classification into domestic and industrial fires, it may be stated, without much fear of contradiction, that where the industrial furnaces are boiler or similar furnaces, and these constitute the great majority, it is possible to burn the coal almost without smoke, and, at the same time, with good economy. This has been proved over and over again, and the recent improvements in coking mechanical stokers, working with forced draught, have made it possible not only to maintain smokeless fires, but to largely increase the output of the boilers.

It is not necessary for a factory owner to purchase an elaborate and special "smoke-consuming" apparatus. All that is needed is to have a well-constructed, hand-fired furnace, provided with suitable flues. If such a furnace is carefully tended and the boiler is not forced beyond its normal capacity, fuel combustion can be effected in it with the production of very little smoke. If, —and this would be still better,—the first cost of a good mechanical stoker could be indulged in, the smoke evil would be still further abated.

With some house fires the case is more difficult. It has been pointed out that there are, at present, no really smokeless open coal fires, and so long as coal is the fuel used and no alterations are made in the construction of fireplaces, there can be no possibility of preventing smoke from domestic chimneys. The fact is, that the public are apathetic, and although most people grumble at the existence of the smoke, the great majority are well content to wait until something turns up, and to allow the few enthusiasts to do their best to obtain a purer atmosphere. If these few do effect a little good, the majority will accept it without thanks, and if the nuisance gets worse, they will only grumble the more. In this matter the individual, even though he may fully recognise the necessity for action, will not make the effort necessary to do his own little share towards the general good. It is this want of interest displayed by the general public that has allowed the smoke nuisance to assume such large proportions.

Legislation, unless of a very drastic and revolutionary character, cannot be looked upon as providing a possible solution. The Act of Parliament under which the smoke nuisance of London is dealt with is the Public Health (London) Act, 1891, Sections 23, 24*a*, and 24*b*. Under the first two sections it is an offence to use a furnace, on premises devoted to trade purposes, so constructed as not to prevent smoke, or to use it in such a way that only part of

the smoke is prevented. The last of the three sections makes it an offence for a chimney (which is not the chimney of a private house) to send forth black smoke in such quantities as to be a nuisance. This section, 24*b*, is the only one which is considered to be of much use in dealing with the nuisance; the other two sections are so crippled with qualifying words as to be practically ineffectual.

The London County Council has no direct control of the smoke, but looks to the Metropolitan Borough Councils to carry the law into force, these being the sanitary authorities under the Act. Where, however, a sanitary authority neglects to take proper action, the Council have power to act, and have, since 1892, given instructions to their inspectors of explosives and to their coal officers to report any nuisance from smoke which may come within their observation. From 1892 until the beginning of the present year 5436 cases were reported to the various sanitary authorities, and in many of these cases the authorities have taken proper action. In the case of railway locomotives and road locomotives also the Council takes direct action with regard to the penalties imposed. These vary from abatement orders, with costs, to fines of £100, with costs, and during the past year twenty-three of the Metropolitan Borough Councils obtained penalties amounting to about £455. During the same period the County Council received £167 in fines in respect to railway locomotives.

From the report of the sanitary committee of the Corporation of London it is learned that during the year 1900 twenty-seven cases were reported as liable to be dealt with under the Act, and all were declared by the committee to be nuisances within the meaning of the Act. The collection of the information necessary for these reports involved no less than 409 separate inspections, so that, although the law is not in all respects satisfactory, in the three districts of the city alone good work is being done by those who are responsible for the public health, so far as their powers allow them; and observant people have been able to detect a distinct improvement in the air of London during the past few years. Although fogs still visit London, as they have done for many years past, they are hardly as dense and pungent as formerly, and this may be taken as one of the best criteria of the general state of the atmosphere.

Signs are not wanting that it will not be by legal methods, whether carried into effect by the local authorities or in consequence of individual effort, that an increasing and permanent improvement in the atmosphere of London may be brought about. Two things most distinctly point to future developments which will all be in the right direction. These are the use of gaseous fuel and the more general adoption of electrical methods.

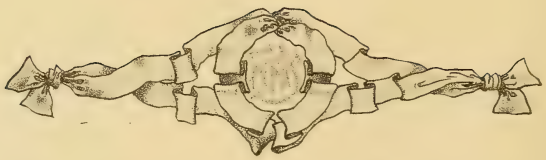
The gas which is used for lighting purposes is now being largely employed for purposes of cooking, and also, though to a smaller degree, for the fires in the living rooms of houses. The more this use of gas will continue to grow, the less will be the domestic smoke. But apart from the inborn repugnance which many people feel to a gas fire in place of a coal fire, the cost of illuminating gas is too great to permit its general adoption. If only the gas companies would provide a second supply of gas, suitable for heating purposes alone, the greatly reduced price of this would give an impetus to the use of gaseous fuel, and one way would be opened towards the lessening of the smoke. A gaseous fuel suitable for heating alone and having no illuminating qualities can be made very cheaply, and could be used in the place of coal for many industrial purposes. If schemes for the distribution for a fuel of this kind can be carried out in provincial districts, why not in London also?

But it is possible to look even a little further ahead, to the time when illuminating gas will no longer be used, and its place will be entirely taken up by electricity. When this comes to pass, London will still be intersected by

countless empty and useless gas pipes, and what would be more natural than the replacing by the gas companies of their present plant with a modified form suitable for the generation of a heating gas to be distributed in the old pipes instead of abandoning them as so much scrap iron. This would mean that the domestic smoke, and that from the smaller industrial fires, would be done away with.

This idea may appear to be rather Utopian, but it may be asked, Who would have dared to predict, thirty years ago, that in 1901 electric light would have replaced illuminating gas to the extent to which it has? As the use of electricity for lighting purposes increases, a point will be reached when, by reason of the diminished demand for illuminating gas, it will no longer pay to supply it. When this happens, the time will have come for the provision of a supply of heating gas.

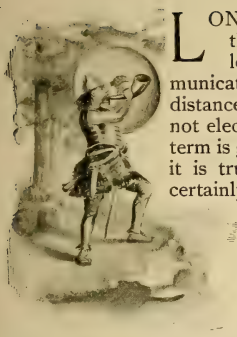
Another possibility, which amounts almost to a probability, is that, in the course of a few years, the development of power will become much more centralised and will be distributed electrically. The further this is carried, the fewer will be the industrial chimneys, and another stage will have been reached towards a complete purification of the London atmosphere.



WIRELESS TELEGRAPHY

ITS PAST AND PRESENT STATUS AND ITS PROSPECTS

By William Maver, Jr., Author of "American Telegraphy"



SIGNALLING BY THE ANCIENT GAULS. THE MESSENGER SHOUTED OR TRUMPETED

LONG before the dawn of the Christian era wireless methods of communicating intelligence to a distance were employed,—not electric telegraphs as the term is generally understood, it is true, but wireless they certainly were, and perhaps as this article proceeds it will not be difficult to perceive a close relationship, as regards the nature of the communicating medium employed, between some of the wireless telegraph systems in vogue thousands of years ago, especially those that employed the luminiferous ether as the communicating medium, and the wireless telegraph systems of to-day, in which case it would simply be another verification of the old proverb, "There is nothing new under the sun."

Polybius, the Greek historian, describes a telegraph system employed for military purposes, 300 B. C., in which torches were placed on high walls in prearranged positions to correspond to letters of the Greek alphabet, and by a suitable manipulation of the torches messages were thus transmitted to a distance. The Gauls, too, were wont to transmit important intelligence to a distance by a cruder but simpler method. A messenger was sent to the top of a hill where he shouted his message, apparently to the winds. Soon from afar a remote voice answered him, and this voice repeated the message to another listener further on, and thus, from one to another, the message sped, and it is recorded that in three days a message calling all the tribes of the Gauls to arms travelled in this way from Auvergne to the forests of Amorica in one direction and to the banks of the Rhine in another.

Later on came another wireless telegraph system,—the semaphore telegraph,—and this was in operation all over Europe prior to, and for some time after, the introduction of the electric telegraph. This semaphore telegraph employed arms on posts akin to those seen to-day along every railway in the world, and a certain position of the arms, like the torches in the Polybius system, corresponded to certain letters of the alphabet, and by varying the position of the arms as required, experts were able to transmit messages from one station to the other at the rate of two or three words per minute. The towers on the top of which the semaphores were erected were often 50 to 60 feet high, and were placed on eminences about six or eight miles apart. In Russia alone there was a string of these towers from the Prussian frontier to St. Petersburg, a distance of 1200 miles or more. Then, after the electric wire telegraph, came the electric wireless telegraph, and perhaps even a cursory review of this subject will show that it is not of as recent origin as it is popularly thought to be. For instance, it is known that over one hundred and fifty years ago electric signals were sent without wires across lakes and rivers. Dr. Watson, Bishop of Landorff, then sent electric shocks across the Thames, and, subsequently, through the New River at Newington. Similar experiments were made by Franklin in 1748

across the Schuylkill at Philadelphia, and by Du Luc, a year later, across the Lake of Geneva. In these instances, however, the water or earth was the conductor of the electric impulses.

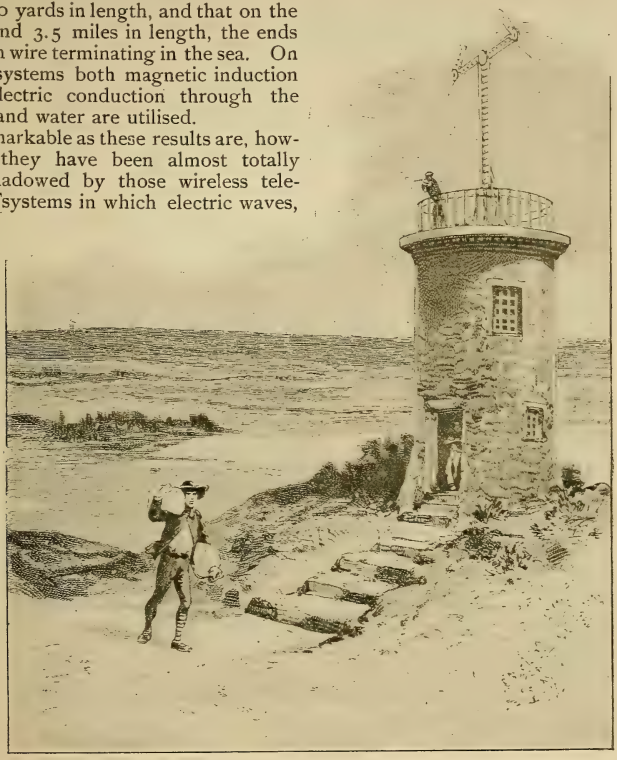
It is fairly well known also that during the past fifteen or eighteen years there have been in limited use a number of wireless telegraph systems which have sometimes been termed induction telegraph systems, and in which electromagnetic impulses, or waves, are employed. Such systems are based upon the phenomena of mutual induction between wires, discovered by Faraday and Henry. Henry's experiments, made half a century ago, were chiefly with flat coils of wire, one opposite the other. When the circuit of one of such coils, containing a battery, was opened and closed, it was found that an electric current was set up in the other coil. This action also takes place between two straight, parallel wires, and when these parallel wires are sufficiently long, and the electromotive force in the transmitting wire is powerful enough, signals may be received in a telephone or other sensitive receiver, even when the wires are separated a distance of several miles.

In 1892 Sir William H. Preece succeeded in transmitting Morse signals by this method to a distance of more than three miles, between Penarth, on the mainland, and the island of Flat Holm, in the British Channel, using a telephone as the receiver. More recently the same experimenter has met with success in establishing a wireless tele-

A VISUAL TELEGRAPH APPARATUS, USED IN FRANCE IN 1792

phone circuitby means of which speech is transmitted between the Skerries lightship and the mainland of Anglesey, —a distance of nearly three miles,—the parallel wire on the Skerries Islands being 750 yards in length, and that on the mainland 3.5 miles in length, the ends of each wire terminating in the sea. On these systems both magnetic induction and electric conduction through the earth and water are utilised.

Remarkable as these results are, however, they have been almost totally overshadowed by those wireless telegraph systems in which electric waves,



A FRENCH SEMAPHORE STATION IN 1795

or ether waves, are utilised, and of which the Marconi wireless telegraph system is the best known. It is of this latter system, as representing, so far as the writer is aware, the most advanced development of this art, that the present article will briefly treat. It would obviously be far beyond the scope of a necessarily limited account to deal with all the wireless telegraph inventions that have been announced within the past few years.

When, in 1864, Clerk-Maxwell, who was, perhaps, the most noted mathematician of his day, made announcement of his celebrated electromagnetic theory of light, which theory involved the existence of electric waves in free space, many of the prominent physicists of the time set themselves the task of demonstrating by experiment the truth of this theory. It was not, however, until 1887 that the actual existence of electric waves in free space was demonstrated, the great honour of this accomplishment falling to Prof. H. Hertz, after whom such electric waves are now almost generally termed "Hertzian"

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GUGLIELMO MARCONI

waves. The old popular idea of electricity hardly conceived it as existing outside of a wire or other metallic conductor. The air was an insulator, and how, therefore, could electricity exist apart from a wire! Maxwell overturned this view, and told us that just as under the undulatory theory of light that which we call light is a result of ether vibration, so also is electricity a result of ether vibration, and that, in so far as light and electricity differ, it is only a question of the rate of vibration of the ether, those undulations of the ether which the eye recognises as light occurring at a rate varying from 400,000,000,000,000 to 700,000,000,000,000 per second, while the frequency of the electric undulations of the ether vary from a few hundreds or thousands to 200,000,000,000,000 per second.

According to the undulatory theory of light, the undulations of the ether, of the frequency just mentioned, are set up by any source of light. Similarly, according to Maxwell's theory, undula-

tions are set up in the ether by any source of electric oscillations, analogously, for example, as waves are set up in the atmosphere by a source of sound. Also, as those ether waves which correspond in frequency to light affect an organ of sight when they fall upon it, and as sound waves affect an organ of hearing when they fall upon it, so, it was reasoned, should the electric waves of the ether affect a suitable electric "eye," or receiver, when they fall upon it.

The manner in which Prof. Hertz proceeded to show the existence of electric waves in free space was, briefly, as follows:—It was already known that electric oscillations could be set up in a well-insulated wire or conductor; in fact, that the discharge of the Leyden jar is made up of a series of electric oscillations, as had been shown by Lord Kelvin in 1853. Hertz set up electric oscillations by means of an electric oscillator, shown in Fig. 1. This consists of an ordinary large induction coil, *A*, the terminals of the secondary coil being connected to small brass balls, or knobs, and to which short metal rods, or wings, *w*, are attached. The knobs are separated by a small air space across which sparks jump when the coil is in operation. At such times electric oscillations are set up, the rate of which varies with the electrical dimensions of the circuit.

Hertz assumed that if the electric oscillations thus produced set up corresponding waves in the ether of free space, these waves should, in turn, set up electric oscillations of corresponding frequency in a suitable receiver, or "eye," within the range of their influence. He, therefore, adopted as a receiver of these waves, a copper wire, *D* (Fig. 1), of nearly circular shape, about 16 inches in diameter, but broken at one point. On the ends of this wire he placed small metal knobs, the distance between which could be easily regulated. This wire was held by an insulated handle, a few feet from the oscillator. With the room darkened, minute sparks were observed passing between the discharge knobs of the receiver; and the results of this simple experiment have been generally accepted as proof of the existence of electric waves in free space.

Hertz, however, was not satisfied with this demonstration of the accuracy of Maxwell's theory, but also, in the course of his subsequent masterly experiments, showed that, like sound, heat, and light waves, the Hertzian waves could also be reflected, refracted, concentrated in parallel rays, and to a focus, etc.

By the Hertz receiver the distance at which electric waves could be detected was very limited, perhaps ten or twelve feet at most, and, hence it is not likely that much would have been done in the

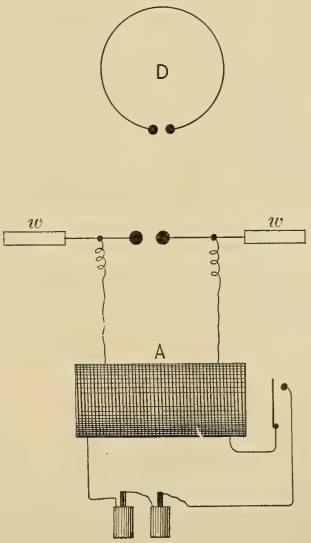


FIG. 1.—AN OSCILLATOR AND A HERTZ DETECTOR

utilisation of Hertzian waves for telegraphic purposes had progress rested there. Fortunately, it did not. Shortly after the experiments of Hertz, Dr. Branly discovered that loose metal filings, which in a normal state have a very high electrical resistance, lose this resistance in the presence of electric oscillations and become practically con-

ductors of electricity. This he showed by placing metal filings in a glass tube and making them part of an ordinary electric circuit (see Fig. 2). When electric waves are set up in the neighbourhood of this circuit, electromotive

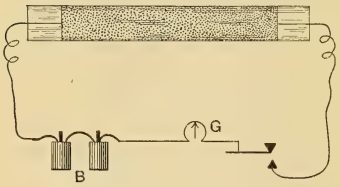


FIG. 2.—A BRANLY COHERER

forces are generated in it which appear to bring the filings more closely together, that is, to cohere, and thus their electrical resistance decreases, from which cause this piece of apparatus,—the tube and its filings,—is termed a "coherer." Hence, the receiving instrument, *G*, in the figure, which may be a galvanometer or a telegraph relay, that normally would not manifest any sign of current from the small battery, *B*, will be operated when electric oscillations are set up. Prof. Branly further found that when the filings had once cohered they retained their

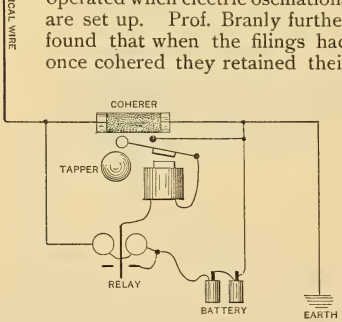


FIG. 3.—LODGE TAPPER AND POPPOFF VERTICAL WIRE ADDED

low electrical resistance until shaken apart, for instance, by tapping on the tube.

In 1894 Dr. O. J. Lodge showed that the Branly coherer could be employed to transmit telegraphic signals, and in order that the filings might not remain "cohered" after the cessation of the electric oscillations, he devised a mechanical "tapper," on the principle of the common electric door-bell, the hammer of which was caused to tap the glass tube as long as the electric oscillations continued (Fig. 3).

The filings thus virtually take the place of a key in the ordinary telegraph circuit. In the normal state the key is open; in the presence of electric oscillations the key is closed. Thus, by opening and closing the key for a longer or shorter period, signals corresponding to dots and dashes may be produced. In other words, by setting up electric oscillations for periods of time corresponding to dots and dashes, messages may be transmitted, and if at the receiving station a recording instrument (controlled by the coherer), such as is used, for instance, in the Wheatstone automatic telegraph system, be provided, a record of the message in dots and dashes is obtained. And this, in short, is what is done in wireless telegraphy.

In 1895-1896 Poppoff and others utilised the coherer to show the existence of atmospheric electricity, using for the purpose a vertical wire connected to the coherer, as shown in Fig. 3.

While Dr. Lodge has since done important work in connection with wireless telegraphy, he was, at the time mentioned, presumably more absorbed in the subject from the purely scientific standpoint than otherwise, and although he then, in 1894, intimated that signals might be transmitted to a distance of half a mile, by Hertzian waves, it was not until Marconi began his memorable work that really practical results were obtained.

In the operation of his wireless telegraph system Marconi uses an electric oscillator (Figs. 4 and 5), the Branly coherer *k*, the Lodge tapper *t*, in a local circuit, and the Poppoff vertical wire *A*, at the sending and receiving stations, all of which devices, as has been shown, were well known, and it,

therefore, has been by modifying, improving, and perfecting these devices, and by adding others, that Marconi has been enabled to obtain his excellent practical results. The improvements and additions that have, perhaps, conduced more than anything else to the first successful results obtained by Marconi were those that related to the coherer and the vertical wire. The sensitiveness of the

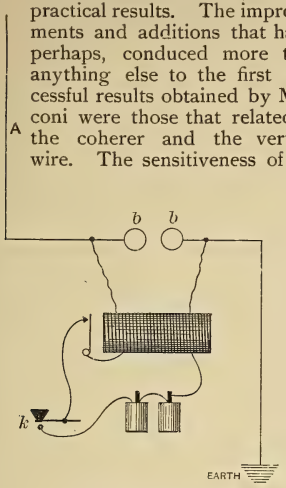


FIG. 4.—DETAILS OF MARCONI'S TRANSMITTING SYSTEM

coherer he increased greatly by diminishing its size, compared with the Branly coherer, and by employing a mixture of nickel filings and silver,—90 per cent. of the former and 10 per cent. of the latter metal. He also placed the few filings used in a vacuum. The other instruments, shown in Fig. 5, are the relay, *R*, controlled by the coherer, and an ink-recording instrument, *E*, controlled by the relay. This figure illustrates the earlier arrangement of Marconi's devices. In it the coherer is directly connected with the lower end of the vertical wire by one of its terminals, and with the earth by its other terminal.

Beginning his experiments in Italy in 1895 with vertical wires 20 feet in height, Marconi found that he could get signals at a distance of one mile, and that by doubling the height of the vertical wire at both stations signals could be transmitted to four times that distance. Thus, with wires 40 feet high he could signal four miles, and with wires 80 feet high, sixteen miles. Since then Marconi has steadily increased the height of the vertical wires, and also the distance to which signals can be transmitted through free space, until in his latest work the vertical wires consist of four parallel wires, 5 feet apart and 157 feet high, and the distance to which signals are transmitted is 186 miles.

The amount of electrical energy employed in setting up the electric oscillations for this present maximum distance of 186 miles is about 150 watts (10 volts and 15 ampères), or about one-fifth of a mechanical horse-power. The source of the electrical energy is a storage battery, which latter is usually charged by a large number of dry cells. In passing, it may be remarked that an ordinary telegraph relay may be operated at a distance of 186 miles at an expenditure of three watts at the transmitting end of a telegraph wire, or with one-fiftieth of the energy used in operating the electric oscillator in question. The actual energy required to operate the telegraph relay is about 0.24 of a watt, the rest of the energy being consumed in the wire itself. It must

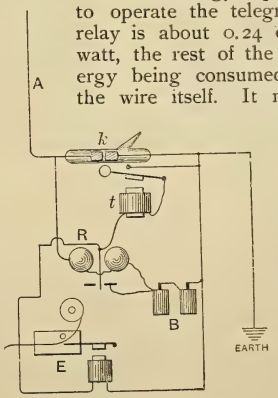


FIG. 5.—OUTLINE OF MARCONI'S EARLIER DEVICES

not, however, be assumed from this that the coherer is a less sensitive electric receiver than the relay; nor will it be, when it is reflected that the electrical energy expended in the case of the relay

is, so to speak, mainly confined to the wire, as, analogously, sound waves are confined within a speaking-tube, whereas the electrical energy of the oscillator is radiated into space in every direction, and thus but a small portion of the total energy reaches the receiving vertical wire. It has been calculated that the electrical energy received on a surface 1 foot square at a distance of but one mile from the oscillator is less than one-three-hundred-millionth of the total energy radiated, and it may be noted, the energy actually radiated as electric waves is a mere fraction of the energy consumed in and at the oscillator.

From the results obtained by Marconi and others, it appears that the effect of increasing the length of the vertical wires is to give a greater radiating surface at the transmitting end and to present at the receiving end a larger surface upon which a greater number of circles of waves may fall, each circle of waves adding to the electrical energy set up in the receiving vertical wire. This view is seemingly borne out by the more recent results obtained by Marconi with a metal cylinder, 4.1 feet high and 1.3 feet in diameter, with which arrangement signals

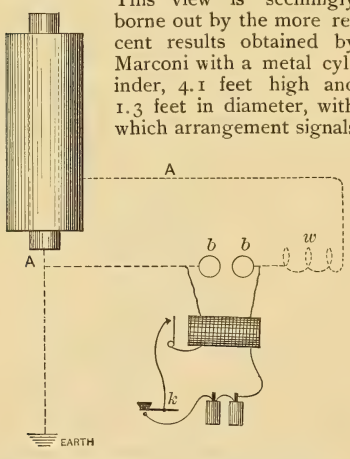


FIG. 6.—MARCONI'S CYLINDER TRANSMITTING SYSTEM

have been transmitted over thirty-one miles. (Fig. 6.)

The vertical wire is usually of stranded copper, about ¼ inch in diameter, although Marconi for this purpose uses also strips of wire netting, about 2 feet broad. The wire or netting is supported by masts of proper height, securely guyed. It is not necessary that the wire be suspended strictly vertically so long as the desired vertical height is obtained. The wire is thoroughly insulated from the mast at the top by sticks of rubber or ebonite, and is led in through an open window or hatchway to the room where the transmitting and receiving apparatus are situated. Although the discharge knobs are separated by an air space of only about half an inch, the induction coil used in connection with the oscillator is often capable of producing a spark that will jump ten or twelve inches through air. The actual appearance of the induction coil, discharge knobs, vertical wire, etc., is well illustrated on the page opposite. The heavy current and high pressures in the circuits of the oscillator have led to the adoption of a much larger key for manipulating the oscillator than is used in ordinary Morse telegraphy.

At an early period of the practical history of Hertzian wave telegraphy it was seen that the usefulness of this art might be considerably curtailed by the fact that but one message could be transmitted between any two stations within the sphere or "radius" of influence of a transmitter, since the attempt to transmit even two messages at one time would result in an unintelligible mixture of both messages. Several inventors have been more recently at work trying to overcome this defect, and, it is claimed, with success, notably Dr. Lodge, Sig. Marconi and Dr. Slaby. The plan followed by these gentlemen has been that of employing a syntonic or tuning method; that is, the transmitting and receiving circuits are adjusted or "attuned" to a given rate of electrical oscillations.

It is a well-known experiment that when two tuning-forks, having an identical fundamental rate of vibrations, are placed in suitable proximity, either fork may be set into vibration by air waves set up by the other fork, and neither will be set into vibration by another fork of a different note. The tuning-

fork is a persistent vibrator by virtue of two qualities which it possesses, elasticity and inertia. When struck a smart blow, it moves from its point of rest; directly its elasticity returns it to its point of rest, its inertia carries it past that point, its elasticity returns it to zero point, inertia carries it past, and so on, until the resistance of the air and other causes stop it. Analogously, an electrical circuit may be given, in almost any desired proportion, the equivalents of mechanical inertia, elasticity and resistance, in inductance, capacity, and ohmic resistance, respectively; and the rate of electric oscillation of a circuit may be varied by varying these factors, — the smaller the factors, the higher the rate of oscillation.

When, then, the receiving circuit of a wireless telegraph system is accurately tuned to oscillate in harmony with the transmitting circuit, which can be done by giving the respective circuits practically equal inductance, capacity, and resistance, the receiving circuit will respond only to the oscillations set up by a transmitter correspondingly tuned. At least, this is, briefly, the theory on which these experiments are based. In experimenting, Marconi and others have, it is stated, found that perfect syntony between the respective stations is not absolutely essential, but that if there is a marked divergence of frequency of oscillation between them, the receivers will not respond to any but their correspondingly attuned transmitters.

The arrangement of Marconi's tuned transmitting and receiving circuits is outlined in Figs. 7 and 8. It will there be seen that the oscillator and the coherer *k* are not connected to the earth, as in Marconi's first experiments, but are kept in electrical connection therewith by a small induction coil *T*. In Fig. 7, *A* is the vertical wire, which is attached at its lower end to a coil of wire, *w*. The end of the wire *d*, which forms part of the secondary wire of the induction coil, *T*, may be connected to any desired turn of the coil *w*. By this means the inductance of the vertical wire circuit may be varied, and its oscillation period thereby be made to correspond with that of the circuit *B*, of the oscillator, which includes the primary wire of *T*; *C* is an adjustable condenser of very small capacity, by varying which the oscillation period of the circuit may readily be varied. An electrical condenser is virtually a Leyden jar, arranged in a convenient form. In this case it consists of a few sheets of tinfoil or cop-

A HERTZIAN WAVE WIRELESS TELEGRAPH STATION

per, the alternate sheets being separated from each other by thin sheets of paraffin paper. A key controls the storage battery circuit, as shown in Fig 7, and, thereby, the oscillator circuit; *M* is the induction coil of the oscillator.

ter circuit is then adjusted so that its oscillation period corresponds with that of the receiving circuit. This is brought about by varying the capacity of the condenser in Fig. 7. The method of obtaining this "balance," as practiced

THE NANTUCKET LIGHTSHIP, EQUIPPED WITH MARCONI APPARATUS BY MEANS OF WHICH ALL PASSING WHITE STAR, CUNARD, AND OTHER ATLANTIC STEAMERS ARE SIGNALLED TO THE NANTUCKET ISLAND STATION SHOWN ON PAGE 224

The tuned receiving apparatus is shown in Fig. 8. In this figure, *A* is again the vertical wire with the turns of wire, *w*, to which is attached the primary wire *d* of the induction coil *T*; *p* is the secondary of the same induction coil; *k* is the coherer, and *C* is a condenser. The induction coil *T* acts virtually as a step-up transformer, which, it is claimed, materially enhances the electromotive forces of the received oscillations, and thus increases the signalling distance.

Marconi has found it important that the oscillation period of the coherer circuit, shown in the figure in solid lines, shall be the same as, or an octave of, the oscillation period of the vertical wire circuit, shown by the dotted lines. This can be done by making the secondary coil *p*, of the coil *T*, equal the length of the vertical wire *A*. The transmitter by Marconi, is to begin with very little capacity in the condenser, and adding to it until the best results are obtained at the receiving station. If, when the best results are obtained still further capacity is given to the condenser in the transmitting circuit, the signals fade away, showing that then the two circuits are out of harmony.

Marconi also found that by means of tuned apparatus a much greater distance may be reached, with a given source of electrical energy and height of wires. For example, a transmitter which would affect a tuned receiver thirty miles away, would not affect a non-tuned receiver 160 feet distant. This, it may be assumed, is because in the case of the tuned receiver the faintest oscillations, or electromotive forces, set up in the receiving circuit by the incoming waves, are in unison with those waves, and successive

incoming waves amplify the oscillations in the receiver circuit until they affect the coherer; whereas the oscillations which the same waves tend to set up in the non-tuned receiver circuit are, so to speak, out of step with the natural rate of oscillation of the non-tuned circuit, and thus as frequently oppose as assist the natural oscillations of the circuit.

In connection with the experiments carried on by Marconi, it is reported that two different messages have been received at one time on a vertical wire, two sets of receiving apparatus, each attuned to a different rate of oscillation, being connected with the same wire. To those who have had experience with Gray's harmonic system of wire telegraphy, in which three and four instruments, attuned to transmit and to receive different rates of electrical current pulsations, have been successfully and separately operated on one wire, this will not appear astonishing, since it is quite conceivable, if it be granted that wireless transmitting and receiving apparatus can be successfully attuned, that two or more receiving instruments might be connected with one vertical wire, and each set of apparatus select and respond only to the particular rate of oscillations to which it is attuned.

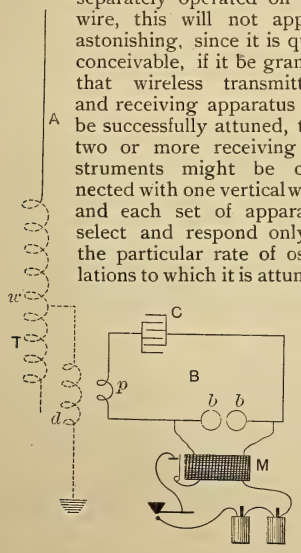


FIG. 7.—MARCONI'S TUNED TRANSMITTING CIRCUIT

However, while the successful operation of contiguous, tuned circuits is quite within the possibilities, it is to be noted that on the occasion of the recent international yacht races, in the United States, off Sandy Hook, when three different sets of wireless telegraph apparatus were in readiness to report the progress of the races, including one set sent out by the Marconi Company, and presumably equipped with tuned apparatus, interference between the different sets of apparatus was pronounced. From France also it is reported, as the results of numerous tests, that freedom from interference with tuned apparatus is not yet secured. But if by the use of tuned apparatus nothing else were gained than the ability with a given amount of electrical energy and a given height of vertical wire, to transmit signals to a greater distance than is possible with untuned apparatus, it must be considered a decided advance in the art, and judging by the whole progress of electrical telegraphy, it is safe to say, when so much has already been achieved, that the necessary improvements to obtain at least practical freedom from interference between adjacent apparatus will ultimately follow.

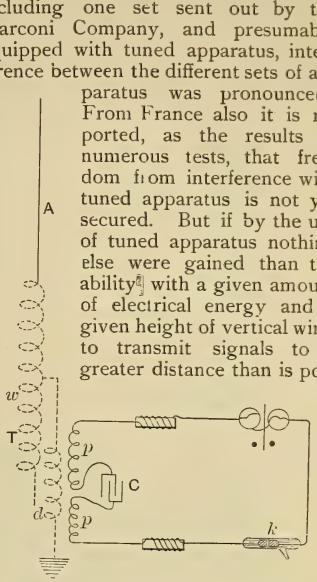


FIG. 8.—THE TUNED RECEIVING CIRCUIT

The specimen of a dot and dash wireless telegraph record given in Fig. 9 is a facsimile of bulletins "caught on the wing" during the yacht races of 1899 in New York Harbour. Mr. Marconi had his apparatus on the steamship *Ponce*, and was sending bulletins of the progress of the race to the Mackey-Bennett cable ship, some miles away, when this specimen and many others

THE WIRELESS TELEGRAPH STATION OF THE NEW YORK "HERALD" AT SIASCONSET, NANTUCKET ISLAND, MASS.

were recorded by a set of Clarke wireless telegraph apparatus which the writer was supervising on the steamship *Le Grande Duchesse*. This was probably the first instance of tapping Hertzian wave signals, in the United States at least. It will be understood that Shr. is an abbreviation of *Shamrock*. Other abbreviations were used in these bulletins, as Col. for *Columbia;* abt. for about; bd. for board, etc. The present speed of signalling by wireless telegraphy is from ten to twenty words per minute; but it seems reasonable to expect that expert manipulators of the key should eventually attain a considerably higher speed by this system.

For practical purposes there is not much doubt that wireless telegraphy will find its greatest field of usefulness between vessels at sea, or between vessels and the mainland, or between points divided by the sea where it is not deemed feasible or profitable to lay a cable. Numerous examples of such uses of Marconi's wireless telegraph system are already in evidence. There is, for example, a wireless circuit be-

tween some of the Sandwich Islands; another between the Lizard, Cornwall, and St. Catherines, Isle of Wight, 186 miles apart, and between Poole and St. Catherines, 31 miles apart. The British Admiralty have also adopted the

Many mercantile steamships have also been equipped with the same system, notably the *Kaiser Wilhelm der Grosse*, of the North German Lloyd Steamship Company, the *Deutschland*, of the Hamburg-American Line, and the ves-

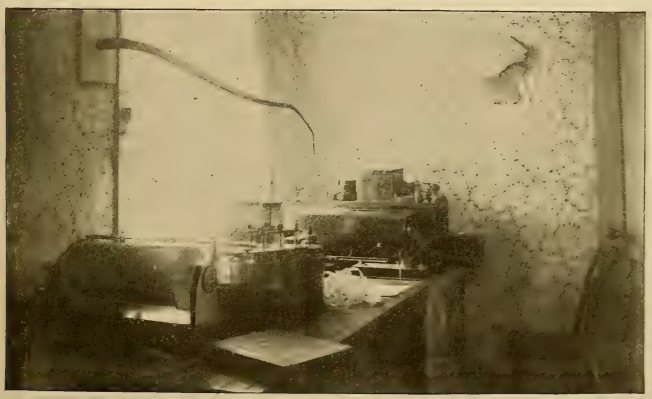
FIG. 9.—SPECIMEN OF A DOT AND DASH WIRELESS TELEGRAPH RECORD

system for many of their warships and for some of their land stations. In all, they have about forty sets of such wireless telegraph apparatus installed. The length of vertical wire of these stations is about 150 feet. The warships thus equipped have signalled each other when 100 miles apart. The wireless system is also installed at different points on the Continents of Europe and America,—at La Panne, Belgium, for example, and at Borkum Island, in the North Sea, off the mouth of the Ems.

A number of lightships have also been equipped with the Marconi system; the

sels of the Cunard Line. Recently the *Etruria* and *Umbria*, of the last-mentioned line, communicated by wireless telegraphy in mid-ocean, and while out of sight of each other, communication being thus kept up for about three hours while the vessels were passing in opposite directions.

There is little doubt that the use of wireless telegraph systems by the navies of the world will become general in the near future. There are several reasons why such systems are especially applicable to, and desirable on, war vessels, which depend so largely on sig-



THE STATION APPARATUS

Goodwin Sands lightship, at the Borkum lightship, twenty-five miles from the island of that name, and the Nantucket lightship, off the Massachusetts coast, from which station passing vessels are daily reported to the mainland.

nalling. For instance, signalling by the Hertzian waves is more successful over water than over land, greater distances being reached over water. The vessels already carry the necessary masts for the vertical wires; the appa-

ratus, including batteries, does not require to be portable; there is at present no other practicable method of signalling at sea to a distance of even a few miles in foggy or hazy weather.

With regard to the use of wireless telegraphy for military purposes in actual warfare, the problem is somewhat different, and the obstacles to its use are considerable. Thus, the question of obtaining and transporting the masts for the vertical wires is a serious one. This was one of the difficulties met with in the South African war. The matter of providing in an easily portable and reliable form the electrical energy required for the operation of the oscillator is also likely to be rather difficult under some circumstances. Should the cylinder lately employed by Marconi be found suitable for land work, this would be a decided gain, and if by this means a reasonable distance, say, fifteen to fifty miles, could be reached by wireless telegraphy, it would be a very valuable addition to military signalling in the field.

There is, however, nearly always in land operations the alternative of wire telegraphy, and while the difficulties of transporting the poles and wires for such systems are frequently very great, they have rarely been found insurmountable, and where such may be the case, as when an enemy is between a relieving army and a beleaguered garrison, it is very probable that the enemy, by keeping up a "crossfire" of electric waves, could prevent communication, by means of wireless telegraphy, with the beleaguered army.

As to the commercial or monetary value of wireless telegraphy, it is yet too early to comment. It is understood that the Marconi Company receives from the British Admiralty £100 per annum, for fifteen years, presumably during the life of patents, for each station equipped. The Borkum lightship is what may be termed a wireless telegraph "pay station," and according to the German postal authorities, which control this station, 565 messages were handled during five and a half months, or about three messages per day, of which 518 messages came from ships at sea, while 47 were transmitted to ships. A large percentage of these messages were to and from North German Lloyd steamers.

Since the first announcement of Marconi's successes with wireless telegraphy many aspirants for honours in the same field have naturally arisen, but so far as actual commercial results are concerned, Marconi has seemingly kept well ahead of other workers along this line, many of whom,—but with notable exceptions, like Messrs. Lodge, Slaby, Guarini, and some others,—while making promises of great prospective results, have deemed it wise to give only the most meagre technical information concerning their devices, on the ground of the unprotected condition of their inventions in the patent office. Indeed, Marconi has also frankly admitted that considerations of this nature have frequently prevented earlier public notice of his improvements in the art which, with the able scientific and financial aid at his command, he may be said to have virtually made his own; but, on the whole, this gifted experimentalist has been so liberal in the quantity and quality of information which he has imparted concerning his improvements that if occasionally he acts upon the advice of Robert Burns to a young friend, "Aye keep something to yoursel' you never tell to ony," it is certainly his privilege so to do.

To obtain the greatest degree of usefulness from wireless telegraphy, when it is employed to prevent collisions at sea, and to send information from vessels in distress, or when approaching or departing from their respective harbours, which are popularly supposed to be the functions for which this system is especially adapted, it would appear to be essential that every vessel sailing the main should be equipped with the apparatus. The writer can say from experience that it requires a considerable degree of expertness to maintain the apparatus in proper working order, and even when code signals only are employed, a fair amount of intelligence is required. It is, therefore, a question

whether the requisite skill and intelligence would be available at all times on all kinds of craft.

There are, however, doubtless a great many places where the necessary expertness of operators is available, and in which, therefore, the full value of the system will be realised. In fact, it may be stated that a vastly larger employment of wireless telegraphy is already assured, since, quite recently, the Lloyds, whose extensive maritime interests are world-wide, have entered into a contract with the Marconi International Marine Communication Company to equip all their coastwise signalling stations with this system, and to transmit and receive messages to and from all passing vessels similarly equipped, at a regular tariff rate of about twelve cents per word, this agreement to extend over a period of fourteen years. Already in the comparatively few instances where the system has been introduced its great utility and importance have been amply demonstrated.

A number of vessels equipped with wireless telegraph apparatus have signalled for aid for themselves and for other vessels in distress; necessary supplies for lighthouses have by this means been procured in emergencies, and in other ways life and property have already been safeguarded by the aid of this latest wonderful utilisation of Nature's greatest mystery, the ether, by the genius of man.

ELEVATORS FOR TALL OFFICE BUILDINGS

THE PROBLEM OF EFFICIENT SERVICE

By Reginald Pelham Bolton, C. E., M. E.

The tall business building, as exemplified in almost every one of the larger towns of the United States, most strikingly in New York and Chicago, where twenty-story structures have ceased to attract attention, and others, higher still, are beginning to multiply, has been largely instrumental in developing the elevator to the remarkable degree attained in the United States. With the tall building the elevator is not a luxury, but a necessity,—a species of railway carrying, in some cases, many thousands of passengers in the course of a working day, and practically deciding the value, as a business proposition, of the building in which it is installed.

Mr. Bolton's article deals with the elevator altogether as a means of handling this traffic expeditiously. It is the economic features of the passenger elevating problem, in other words, and not the engineering features of the elevating machinery, which he has here taken up, and his close identification with this and other problems in tall building equipment gives a special value to his conclusions.—THE EDITOR.

FROM the points of view of both the owner of property and the tenant, the subject of elevator service in modern tall buildings is of direct interest. It is a remarkable demonstration of the rapidity of the development of the demand for such a combined appliance as the building and its elevating apparatus constitute that no comprehensive information has yet been published on the subject of their relative proportions. In point of fact, a practical work on the general subject of elevators has yet to be written, and the following considerations may, perhaps, point to the desirability of its eventual compilation.

The modern office-building may be regarded as a compound mechanical contrivance for the conduct of general business. Placed in a certain advantageous position, which, owing to that desirability, is limited in area by a resultant large value, it is enlarged vertically, and provided with numerous modern details of comfort and convenience for the purpose of enabling its tenants to perform the largest possible amount of business transactions by the least expense of individual or hired efforts, and with greatest economy of space and time.

The inexorable law of gravity, however, is, by the superposition of habitable areas, directly opposed to a convenient access, in a ratio proportionate to the height at which the respective tenants are placed, and mechanical apparatus, therefore, becomes a very essential feature in the results desired. As time is the essence of business success, it is evident that the more remote or upper portions of such structures are at a disadvantage, compared with those nearer access to the street,—a consideration only partly outweighed by advantages of superior light, air, and outlook.

The development of the elevator in the direction of extended lifts and increased speeds has been only a partial response to these conditions. It is evident that the present system of service only approximates or averages towards the theoretical completeness of a service which should afford each floor an access to the street of an exactly equal minimum extent of lost travelling time,—a result which would be attainable only by a separate elevator to each floor, of a speed proportionately increasing with each superposed floor. This, however, is a combination manifestly impracticable. The attempts to effect some practical approximation towards this desideratum have, moreover, been, in the hands of architects, rather futile, as might be expected when such a technical problem of railway engineering is attempted by a class of men who, how-

ever practical in their own proper element, are amateurs in this other field.

Serious blunders have been made and great damage has been done to the future value of such properties by assumptions and errors in the locating and proportioning of elevators, and it will probably be only a few years before very radical changes will require to be made in some of the noted tall buildings if they are to retain their rentable values. Nor are such problems to be properly settled upon the advice of manufacturers of the apparatus involved, whose information, wide though it may be, is not of that independent character necessary for unbiased decision on such a subject. It is no reflection upon their capacities to state the fact that their willingness to make their machines comply with any suggested disposition or malproportion of service has helped in many a misguided decision.

We have now sufficient data to decide the number of residential and visiting travellers which a building of any given proportions and location will afford; and in the handling of these people a problem of traffic is presented much on the order of that of a suburban railway whose equidistant stations serve an almost fixed number of passengers, regular in habit, between whose movements are to be handled a floating traffic of visitors.

In one respect, however, elevator service has a more definite element than any railway, since every passenger carried to a destination must be returned to the point of departure, whether it be intermediate, or local, travel, or to and from the terminus. The parallel with railway conditions is further extended by imagining that the stops are not scheduled, but dependent on instructions from the interior passengers, or on visual observation of others waiting at stations.

When it is remembered that the distances between stations average only 10 feet, and that modern speeds of elevators cover this distance in one second, the importance of any system which will notify the operator in advance of approach is very manifest. The increase of travel has, fortunately, brought about the development of such systems, and their adoption has greatly increased the capacity of the service in every instance.

Not only from the point of view of economy in time, but in power, the signalling of cars by waiting passengers is a primary necessity of office-building service, since every return to a floor once passed means a corresponding loss of power and a totally unnecessary number of starting shocks to the apparatus.

It is, of course, necessary, even with these aids, that there should be a certain amount of intelligent co-operation between the passengers and the operator. The travelling public have undergone some education in this matter, and have learned to enter and leave cars promptly, to understand the necessity for signalling, and for notifying the operator in advance of their destination. These matters comprise the human element in the conduct of any elevator service, and are capable of beneficially affecting results to quite a substantial extent.

The operators are now required in New York to pass an examination as to their knowledge of the operation of a car. It would be desirable if the enquiry extended to their methods and behaviour during the course of their duties. Some excuse must be made, however, for the conditions under which they are expected to work. Standing, as they do, for hours, frequently engaged continuously in the severe muscular exercise of opening and shutting the absurdly heavy gates with which architects continue to burden the service, it is not to be wondered at that they become careless or surly. Their hours of labour should be under regulation, and there is no more reason why they should not be afforded a support than there is in the case of the locomotive engineer. Such provisions, with the replacement of heavy gates by light patterns, or by the automatic system of operation, will improve any given service.

It is not necessary to dwell upon the

necessity for a schedule system of starting from the terminus, nor upon the judgment and decision required in a good "starter." One method of meeting the fluctuations in the travelling numbers has been to provide, as far as possible, large cars, equivalent to a few heavy, long railway trains, proportioned to run at high speeds,—in other words, hauled by express locomotives. Both elements are manifestly faulty. Such a traffic is to be handled by trains of moderate weight, powered not so much to make speed in numerous short runs between stops as to reduce and regain speeds with the least possible loss of time and with equal results in both directions, and, above all, to lose as little time as possible in transferring passengers in and out.

The practical desiderata, therefore, are firstly, wide, shallow, light cars, with the amplest opening in cars and at landings for access and egress to proceed at the same time; secondly, such starting and retarding control as will, without shock and in minimum time, arrest and regain normal speeds in both directions.

Much has yet to be done by manufacturers to secure these results. At present when the arrest on upward travel is good, that on the descent is bad; and inversely, the resumption of speed is excessive on the down-travel and sluggish on the up travel. These lame results are aggravated by the use of absurdly heavy, overdecorated cars and corresponding masses of counterweights. Given the foregoing practical elements, the problem of proportioning the elevator service to the expected traffic remains.

The traffic must, of course, be settled in each individual case by consideration of the conditions, inasmuch as the location of the building is fixed. It may be varied by some special tenancy of a portion of the building, such as, in one case, where the eleventh floor of a building accommodates a class of several hundred law students having fixed hours of entry and departure, or as, in another case, where the offices on the upper floors accommodate about 450 employees, all arriving and departing within a few minutes at fixed hours.

However, such special conditions may be met by some short temporary diversion of the regular schedule, as, in the former instance, when at the hour of dismissal of classes, the crowded descending cars discharge the students at the mezzanine level and immediately return empty to the eleventh floor for another load, while two or more cars are directed to make no stop at the eleventh on their down-trips. Incidentally, this very practical result may illustrate the desirability of a mezzanine gallery in the main hall, corresponding, as it does, to an overflow or extra service platform in a terminus,—a point strongly to be commended to the attention of owners and architects.

It may be pointed out here that a very common arrangement of public toilet rooms on a central floor has a distinct disadvantage in adding to the intermediate traffic and reducing the general capacity of the service.

Where conditions are normal, the traffic at all floors may be assumed to become practically equal. And since it is impracticable to afford each floor its own separate connection to the terminus, a choice must lie between passing certain floors by assigning to them express cars, or serving all alike, relying on a natural assimilation arising from the fact that while the upper floors are at some disadvantage in point of time occupied by the journey, it is not a stable disadvantage, since the average is somewhat better than that of a trip stopping at every floor; and, moreover, the lower floors lose some of their facilities by reason of overfilled cars passing them on the down trips. Consideration of these two features will show that some of the upper stories' loss in speed of travel is repaid in amount of mileage at their disposal as against lower stories.

It is not, therefore, a step in the direction of equalisation of traffic to establish an express traffic to certain upper stories, unless a corresponding number of local or stopping cars are withdrawn from service. This is the mistake which has been and is still made

in many buildings. For instance, one building which the writer has in mind, having five cars, operates two as expresses, without stop below the fourteenth floor, while the other three cars operate the lower fourteen stories, but also proceed to serve the floors above the fourteenth.

Thus, as between the thirteenth and fourteenth floors the widest possible difference exists. Whereas a tenant on the fourteenth floor has a car passing his station once every forty-two seconds, his neighbour, 11 feet below him, has only three cars at his disposal, calling every sixty seconds. And whereas the upper inhabitant may make 1080 trips a day and any rapid trip in twenty seconds, or may average his trips, using all five cars in turn, at twenty-eight seconds per trip, his lower neighbour cannot better thirty-three seconds on any trip, and has only 540 trips per day at his disposal. The latter is, in effect, by this disposition placed twice as far from the street as his more fortunate neighbour. At the best, such an arrangement should carry an equivalent consideration in respect of rental.

The disadvantage is increased to tenants of still lower floors, because they suffer also from the overcrowding of the local cars, and are thus afforded a less desirable service. The same inequalities will, in degree, be found in such proportionate services as that of one prominent New York building in which there are four local elevators to the seventeenth floor, and two express elevators to the ninth and beyond, and that of another in which there are six cars to the sixteenth floor and two expresses to the tenth and above.

All such services would be improved by arranging that an equivalent in local cars should serve those floors missed by the expresses. It does not follow, however, that these short locals should be of equal speed or mileage to the expresses, since they have a less average distance to travel.

This feature has been appreciated in very few buildings, the most conspicuous example of reasonable arrangement being in the twenty-story Empire Building, in New York, in which five cars operate to the eleventh and five above that floor, the whole service being very amply proportioned.

The St. Paul Building, in New York, illustrates another faulty disposition of travel. There only six cars are installed, of which two serve to the eighth floor only; two from the eighth to the sixteenth floor only; and two from the sixteenth to the twenty-fourth only. In this case there are practically three superposed eight-story buildings, of an area of about 4000 square feet, served in each case by only two elevators,—a proportion which would be considered manifestly insufficient in such a building independently situated.

In a paper upon the subject of "The Tall Buildings of New York" presented, in 1900, to the Institution of Civil Engineers, the writer advanced the proposition that the extent of car passage past a given floor could be proportioned upon the area of that floor, inasmuch as the average tenancy and consequent visitation of a given area of floor is now pretty well established. The writer's experience led him to suggest a relation of one elevator to an area of 1000 square feet rented space, repeated on sixteen floors; that is to say, that the tenants of that area superposed are to be adequately served by one car moving under present average operating conditions.

Office buildings of this height, which are a numerous class in the United States, vary in area from five to seven thousand square feet, and, on the above basis, would require from five to seven cars. This basis must not, however, be assumed to be capable of application to the same area at any other height, since that would ignore the effect of increased distance of travel and consequent reduction of the capacity in trips made by a standard car Neither can the proportion be maintained by mere increase of speed of the elevators, as has been frequently attempted, since there is a practical limit to the operating speed of elevators, due to the unpleasant sensations of rapid down travel, and also to the difficulty at high

speeds of stopping level with floors. The true basis of calculation is the capacity in number of opportunities of access at the average or middle travelling level. As the lower or upper stories have special relative advantages and disadvantages, so the middle floor may be assumed to represent a medium condition, and the car passages past that point, and the average stoppages, may be based on provisions at that level.

The general form and proportions of cars in New York are greatly at fault. In the first place, their carrying capacity is commonly fixed by some structural arrangement of the steel cage, some architectural fancy, or an assumption of a passenger per floor. None of these elements have any bearing on the proper proportions. When a properly proportioned service is maintained, the desirable area of the car is affected much more by its shape than by its capacity.

Nearly all cars are too deep, and narrow entrances are the rule, so that time and travel are lost by passengers struggling in and out. Cars whose width exceeds their depth, and the doors of which fold back as nearly the full opening as possible, are more convenient and economical than such affairs as are to be seen in most of the leading office buildings. The deep embrasures in which many car entrances are placed are also a distinct tax on the service, obstructing the prompt access of passengers and the vision of the operator.

On the position of elevators there appears to be, if one may judge from what one sees, equally little basis of practical knowledge. One set of architects is wedded to the semicircular arrangement; another to their disposition in line; and another to divisions facing each other. The best results in each are generally discounted by the malproportion of hall space, of deep recesses, narrow doors, or of access and egress from only one point in narrow halls.

It is, of course, manifest that a typical disposition could not be adapted to all conditions of property area and access; but it may be pointed out that less traffic can be got out of cars divided so as to face each other across a hall, or where, as in one case, the express elevators are situated at right angles some distance from the local cars. This latter is a very poor arrangement.

The semicircular arrangement appears the most reasonable way of bringing all doors into view of the passengers; but it should not be complicated, as has been done, by extending others at the wings beyond the semicircle, with the result that these side cars are liable to be neglected, and their value thus not properly developed. In the majority of cases it is probable that the cars are necessarily to be placed in line, and it is then desirable that their openings should be of the widest form possible, and free from architectural obstructions.

A word of protest may not inappropriately be here directed against the practice of ornamentation of entrances and interiors of cars. Such decorations are as inappropriate in a mechanical apparatus of this character as were the early elaborations of the railway car builders. In the latter the modern tendency is all towards a strict simplicity of decoration and an absence of superfluous ornament, with diminution of useless encumbrances. In an elevator car the addition of a single pound of unnecessary weight in the form of ornament is a loss to the owner, and a sin against that essential canon of appropriateness to which architects, in their eager desire for effect, are especially liable. There would be more excuse for decorating the sides of elevator shafts than there is for the elaborate ornamentation of car interiors.

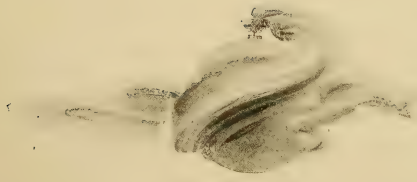
Much more attention could usefully be paid to such matters as closing the open spaces between landings and edges of the cars, covering the tops of cars as a protection against dropping grease and other objects, and carrying the closed panels of cars higher than is now done. It is a question whether the open grillwork commonly used for sides and top is not a source of danger; but certainly in case of fire or smoke in a shaft the nearer the car approaches to a

closed compartment, the greater its safety,

This brings the subject to a matter of great moment which for several years past the writer has urged upon architects and owners, namely, the enclosure of each elevator shaft separately from others, and the cutting-off of open elevator hallways from the stairways,—both provisions which may prove of vital value in case of fire or smoke. As now arranged, the shafts and stairways, which nearly always are in close contiguity, are simply funnels or chimneys to which, in case of fire, all smoke and flame are directed, and down which all water is poured.

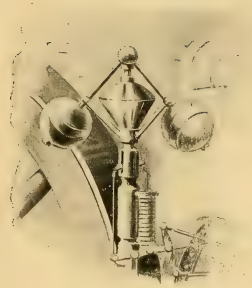
One would certainly imagine that the mere convenience of cutting off the noises of the elevators and their doors would induce the former arrangement, and that the authorities, who are supposed to safeguard the heedless public from unforeseen dangers, would ensure the latter.

As it is, a very small amount of otherwise innocuous fire may precipitate a fatal panic when tenants find their entire means of egress turned into smoke flues. Besides, the schedule services are accompanied by an amount of noise that adds to the nervous strain of modern business life.



THE FUTURE OF ELECTRICITY SUPPLY

By W. S. Barstow



AS the electrical engineer of to-day who has followed the progress of electricity supply during the last ten years views the present situation, he often wonders, especially if he be acquainted with recent developments, what further changes the future will bring forth. A few years ago power plants of a total capacity of 250 horse-power were "large," and many an engineer was criticised for advanced ideas. Soon direct-connected units met the demands of valuable floor space, the size of plants increased, and the business of electricity supply took on an air of permanency, both in the commercial and financial worlds. Up to this time, however, it was necessary that the energy be suited to the purposes for which it was to be used, and the different systems of generation and distribution were seldom interchangeable. Each plant demanded an individual design, both as to its steam and electrical equipment and method of distributing the energy, and this fact did more than anything to retard consolidation of electrical supply interests in large cities.

Then came a revolution. The multiphase system came into use, and the practical electrical engineer at once saw its almost unlimited field of application. With multiphase current forming a universal system of supply, easily capable of conversion so as to adapt the form of energy to any of the existing distributing systems, it was not surprising that the possibilities in actual consolidation of properties should attract the attention of financial interests. Systems hitherto separately operated were brought together, former generating plants were abandoned, and the supply was standardised and generated in one large central power house, irrespective of the nature of the energy furnished by the distributing system. With the practical economical results of such engineering in evidence, the difficulty of securing capital for large enterprises was, to a great extent, overcome, and electricity supply at once took its position among permanent and standard industries.

When it thus became possible to combine properties, even in themselves of large proportions, new designs in the generating plant were demanded to provide for the very sudden increase in the output of the single station. Engines and generators hitherto restricted to comparatively small sizes, owing to the nature of demand in individual stations, became too small when called upon to meet the combined requirements. Within a period of three years the size of the generator unit grew from a maximum of 1000 horse-power to 8000 horse-power, and although difficulties, hitherto not apparent in small generating plants, made their appearance when larger units were demanded, modern engineering skill was fully equal to the emergency. The multiphase generating station of to-day knows no limits electrically, either in the extent of area supplied or the class of energy furnished, its field being governed only by local financial conditions.

Although the introduction of a uniform transmission system has, to a certain extent, simplified the details of the generating station, still it has, up to the present time, left undisturbed the dis-

tributing systems. To conform the multiphase to the existing conditions in methods of distribution it has been necessary to make use of certain transforming devices, which, although seemingly complicated in their installation, develop high efficiency when under actual operation, and show a minimum of operating expense. To omit these at this time would not be possible, unless we abandon the distributing systems already installed.

It is an interesting fact, but an all important one, that during the evolution of the past fifteen years when the detail equipment of the generating station has been modified again and again the distributing system has experienced very little change, even in the large cities. The direct-current, three-wire, low-tension system, without any general modifications whatsoever, is to-day in the same position that it was about fifteen years ago as to its being the most economical and efficient system of distribution for compact territory.

The alternating system of distribution, practically up to the present time a house-to-house supply, although modified from time to time, still exists to-day, as it did in the past, the only economical means of distribution in scattered territory. Many changes will, therefore, have to occur, not only in the distributing system itself, but also in the devices which it supplies, before the present methods of distribution in large or small cities will be supplanted. Even when this time apparently occurs, the difficulties of changing a system which has been in use for so many years, affecting, as it would, the property of the customers, will make a very difficult task, and one where financial conditions will play the all-important part. That this change may eventually take place at some later date, and a universal distributing system, similar to the universal generating system, be used, there is no doubt, but before such a point has been arrived at, several intermediate stages of development must be passed through. This is especially the case where multiphase current is transformed into direct current for railway purposes.

The multiphase, or universal generating station, has given a special impetus to the rapid development of all transportation propositions, and has in many cases made possible competition with steam railway systems. Electric transportation up to the present time, unlike lighting and stationary power supply, has been developed entirely by the use of direct current, there being no widespread direct application of the alternating current for the purpose.

Owing to the present extensive development of direct current as a standard for operating railways, the introduction of the transforming device between the multiphase alternating transmission system and the direct-current distributing system will continue to be an absolute necessity. That alternating-current multiphase railways will be developed in the future for high-speed long-distance roads, where the stops will be seldom and the distances between them long, there is no doubt; but such a system will not enter the fields of large urban traffic, at least surely not until such a time as a device is forthcoming for the alternating-current system which will replace the storage battery of the direct-current system.

It is, therefore, safe to assume, in view of the foregoing, that the most economical system of electrical supply for some years to come will consist of the present, recently developed, multiphase generating station connected to sub-stations in which will be located the transforming apparatus as the connecting links to the distributing systems already in use.

The practical man of to-day, whether engineer or financier, in reviewing the progress of the past few years, cannot help but wonder whether a limit has been reached in the ultimate size of this generating plant. As it is already practical to consolidate various systems and supply them from one generating station, would it not also be possible to combine, in turn, these large generating plants when they are located in the same territory,

so that all energy can be distributed from one central point? It seems almost improbable that this development should ever occur, when we consider the size of the plants now being erected in London, New York, or Chicago, and yet the carrying-out of such a proposition is by no means an impossibility or even an improbability.

The question as to the ultimate size of the main generating station, and the number of sub-stations that can be operated from it, is limited only by the development of details in the design and operation of generating machinery. It is true, the efficiency of electrical equipments of the present day has reached a very high figure; but the fact that the steam plant rarely exceeds a heat efficiency of 10 per cent. points out some of the possibilities of the future. There was a time in the history of generating stations when labour was an all-important item, and when fuel amounted to rarely more than 15 per cent. of the total operating expenses. As the size of the generating units has increased and the station machinery has become simplified, the percentage of labour in operation has been reduced to a very large extent; in fact, almost to the limit of reliability of service.

Fuel, on the other hand, has formed, and will continue to form, an ever increasing percentage of the total station expenses, and the problem will, sooner or later, resolve itself into that of transmission of energy by electrical conductors *vs.* railway. This may mean another change in the location of the main generating plant, and the present large station may itself, in turn, become a sub-station, or be abandoned altogether. When several of the present stations which supply sub-stations shall give way to one large generating plant of many hundred thousand horsepower capacity, located in close proximity to the coal fields, then, and not till then, may we even look for a cessation in present multiphase progress. The importance of the coal industry in connection with the development of electrical problems is becoming more important, and any radical movement, such as this, might bring about further combinations with properties at present transporting the fuel, and which by that time may themselves be electrically operated.

The question of operating such combined enterprises by electrical energy generated by water power is not to be considered in such a colossal undertaking, since the average water power of to-day, more or less limited in ultimate capacity, would form but one small unit in the general plan. Such enormous development as the combining of present already large properties may be thought more or less visionary, due to the apparent difficulty at the present day of suiting the size of the generating unit to new economical conditions; but the fact is always evident that when the proper conditions arrive there will be no lack of engineering ability to successfully overcome obstacles which at this time would be seemingly insurmountable Who can say that such a practical combination of present large interests shall be impossible within the next ten years, after reviewing the progress of the ten just past?

THE ELECTRIC INCANDESCENT LAMP

HOW IT IS MADE AND TESTED IN THE UNITED STATES

By Bernard V. Swenson, E. E.

A GENERATION ago the industrial use of electricity was practically confined to telegraphy and electro-plating. There was no hope and hardly any thought of making further applications until the advent of the commercially successful dynamo in 1871. Although there had been a small amount of electric arc lighting, notably in the streets of several cities of Continental Europe, and in some lighthouses, industrial electric lighting really began at that time.

The incandescent lamp is based upon the principle of raising the temperature af an electrical conductor by means of on electric current traversing it. Since the intensity of the light emitted increases very rapidly with the temperature, high temperatures should be employed and the substance used should possess a high fusing point. Furthermore, the heat should be concentrated within a small space, to avoid cooling effects as far as possible. The material used should, therefore, be a moderate, or comparatively poor, conductor of electricity. The substances which have been most commonly employed in the development of the incandescent lamp have been platinum, iridium, alloys of iridium and platinum, and carbon prepared in various ways. The industrially successful incandescent lamp dates from the commercially successful production of carbon filaments.

In 1841 an Englishman, named de Moleyns, applied the principle of simple incandescence, out of contact with air, using a platinum wire in his experiments. In 1845 Grove, the inventor of the Grove battery, described a form of incandescent lamp, which, he stated, he had used as early as 1841. In 1848 Pétrie took out a patent in Great Britain covering the preparation of iridium wires destined for electrical lighting. But these first attempts seemed to have been forgotten several years afterwards, when, in 1853, de Changy published his method of lighting with an incandescent platinum wire rolled in a spiral. This method was somewhat similar to that used nearly twenty years later in the early attempts immediately preceding the introduction of the successful carbon filament lamp.

The principal objection to the use of platinum, aside from its excessive cost, is the fact that its melting point, about 1775° C., is but slightly above the temperature at which it produces a good white light. A slight increase in the electric current produces the critical temperature. Such a lamp would be impracticable to-day, while in the early days they were unable to regulate the current even in an approximate manner.

FIG. 1.—THE GROVE INCANDESCENT LAMP OF 1841

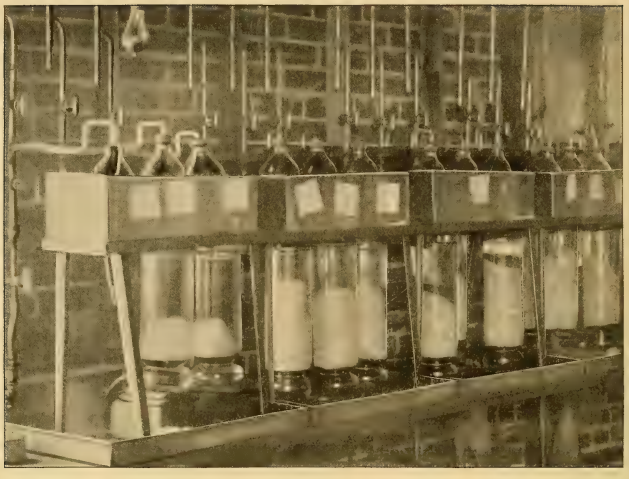


FIG. 2.—SQUIRTING THE FILAMENTS

The fusing point of iridium is about 1950° C., and while it could, therefore, be used at a slightly higher temperature than platinum, it was practically no better for the purpose in hand. Lamps with metallic wire filaments were condemned to remain at comparatively low temperatures, emitting light decidedly yellow in colour, often looking more like red-hot hairpins than practical artificial light sources.

Less fusible substances were necessary so that higher temperatures could be safely used, giving a whiter, as well as a more economical light. Although such substances were available, most of them could not be made into filaments, and nearly all of them burned readily. This latter difficulty was overcome by producing the incandescence in a vacuum.

It is probable that the true originator of the idea of using carbon to produce incandescence was a poor American scientist named Starr, who was aided financially by Peabody, the great philanthropist. Starr exhibited his lamps in Great Britain in 1845, but died on the return voyage to America. Several patents on incandescent lamps were taken out in Great Britain about this time; but, in spite of the promising beginning, the whole matter lay practically dormant for more than twenty-five years.

It was in Russia, in 1873, shortly after the dynamo began to be used industrially, that the incandescent carbon lamp was next heard from. Between 1873 and 1876 these Russian lamps were improved, but were not very successful, as the filaments burned out quickly, owing principally to the very imperfect vacuum secured.

The famous experiments of Crookes, in England, in 1877, upon light in a vacuum, showed the advantages of using the Sprengel mercury pump for exhausting lamp bulbs. About this time greater activity began to be manifested in lighting by incandescence, the success of arc lighting proving a stimulus, and in the next four years the incandescent lamp was evolved, as far as its essential features are concerned, practically as it is to-day.

The story of the development of the incandescent lamp has been told many times. The trial of powdered graphite, the use of carbonised bamboo, the

search, at great expense, for better substances, and the return to bamboo, the use of silk thread, paper, jute, and cotton are no doubt familiar to most readers. It seems remarkable that such an amount of money and energy was wasted in the attempt to find the proper substance for an incandescent lamp filament when we now know that the material from which it is made is not a matter of so much importance, so long as it receives the proper treatment. At present cotton is used almost exclusively in the preparation of ordinary filaments.

The first lamps were very high-priced, and the great problem was the reduction in cost. At first the filament was made fast to the platinum leading-in wires by means of costly clamps and screws. Later, these were done away with by covering the points of attachment with a layer of electrolytic copper, which not only made good electrical connections, but also stiff joints. Still cheaper methods were afterwards introduced, such as the deposition of carbon itself upon the joints and the employment of special cements. A further economy resulted from reducing the length of platinum wire necessary for the leading-in wires. A serious question was the exhaustion of the air from the lamp bulbs. Mercury pumps were almost exclusively employed at first, but these have yielded to mechanical pumps which do away with the mercury altogether, and depend upon chemical processes within the bulb for the completion of the vacuum.

Although used so universally, very few, even of those who have spent years in the electrical business, have ever actually seen an incandescent lamp in the process of manufacture. Indeed, a very small number have any conception of the many and intricate processes involved. The best absorbent cotton is generally used as the basis of the filament. The raw cotton is placed in a pot or vessel, treated with zinc chloride, and worked to a pulpy mass, being subjected to a temperature about that of boiling water, the operation taking about an hour. This pulpy mass is reduced to a density which permits of filtration, and is then carefully filtered through fine-mesh platinum filters.

After being filtered several times the density is brought to the desired value for what is known as the squirting process. The "mass," as this pulpy material is called, is then placed in spheroidal-shaped vessels, which are provided with openings at both top and bottom (Fig. 2).

The lower ends are provided with platinum dies, the openings in which are of sufficient size to permit the passage of the mass and form it into a thread of a certain diameter, dependent upon the kind of lamp desired. At the upper end of the spheroidal-shaped vessel there is an opening which is connected, by means of a rubber tube, to either a source of air pressure, or to a vacuum, as desired.

The spheroidal-shaped vessels are placed in a water bath and are subjected to a temperature of about 75° C. Any air or gas bubbles which may be in the mass are removed by subjecting the jar to a vacuum, and the "squirting" of the filament is then commenced. This is accomplished by subjecting the mass to an air pressure which

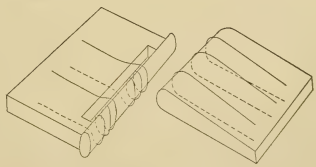


FIG. 3.—FILAMENT FORMS

varies from four to twelve pounds per square inch, depending upon the condition of the mass, the temperature, atmospheric conditions, etc. The temperature of the water bath at the time of squirting the filament is about 90° C., although this is also subject to some variation due to general conditions.

The filament passes from the die into a glass jar which is filled with methyl alcohol containing a 10 per cent. solution of hydrochloric acid. It immediately hardens in this solution, and the acid neutralises any alkaline effect which

FIG. 4.—CALIBRATING AND "FLASHING" THE FILAMENTS

may have been retained from the zinc chloride treatment. At this point the filament is of a yellowish-white colour, and as it slowly passes through the die and coils itself in the alcoholic solution it looks very much like vermicelli. After remaining in this solution for three or four hours, the filament is washed in acid solutions, in pure distilled water, and finally in a bath of methyl alcohol, the entire washing process taking about twenty-four hours. It is then wound upon velveteen drums which are about 18 inches in diameter, and is allowed to dry. When thoroughly dried, it is cut to the desired lengths, and the individual filaments are made up in bunches of ten or more. This is accomplished by winding from the drum upon a spool, the circumference of which is equal to the length of filament desired. By winding a certain number of turns and then cutting across the turns, filaments of the desired length and of the proper number for a bunch may be obtained. They are next wrapped around carbon forms to produce the desired shape, as shown in Fig. 3.

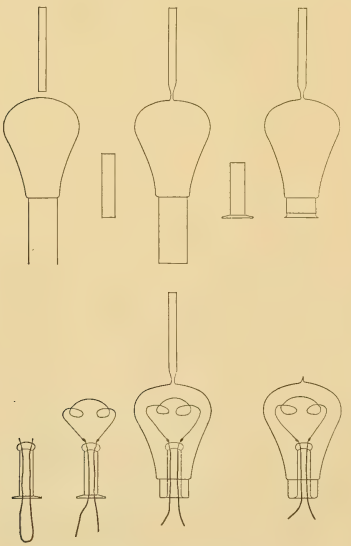


FIG. 5.—STEPS IN LAMP MANUFACTURE

These forms, each accommodating a number of filaments, are placed in a crucible and packed in graphite, there being first a layer of graphite, then a number of forms, etc., the top layer being graphite. The cover is then placed on the crucible and the whole is

sealed, small openings being left for the escape of the gases which are driven off in the carbonising process.

The crucible is placed in the carbonising furnace and the temperature is gradually raised to about 2500° F. and maintained at this point for about twenty-four hours. The temperature is then raised to about 4500° F. and kept at this point for several hours longer, after which the crucibles are allowed to cool slowly. The time occupied in the carbonising process depends upon the size of the filaments, and for very large filaments may be much longer than the just-mentioned period. The crucible is finally unpacked and the filaments are removed, the graphite and forms being preserved for further use. The filaments at this point are inspected for brittleness and evenness of surface. A certain number from each crucible, about fifty out of five thousand, are passed ahead through the various processes of manufacture and made up into finished lamps. These are tested on a forced life test,—40 per cent. above normal voltage,—and if their performance is good, the remainder of the carbons are placed in stock; otherwise they are destroyed.

The filaments are next measured for length and diameter, and are carefully sorted. Since the cellulose-like thread is wound on the velveteen drum while it is still soft, its cross section becomes somewhat elliptical, and it is, therefore, necessary to measure both the maximum and minimum diameters in order to determine the true cross section. After having been sorted in this way the filaments are again classified according to their electrical resistance, and are then ready for the "flashing process."

FIG. 6.—FLANGE MAKERS AND STEM ROLLERS

The earlier forms of filaments were far from being of uniform cross section, and the flashing process was introduced to render them more uniform. The process consists essentially in placing the filaments in a jar containing hydro-

FIG. 7.—A STOCK ROOM WITH HALF A MILLION LAMPS

carbon vapour,—generally gasolene or pentane,—and raising them to incandescence by sending an electric current through them. The high temperature decomposes the hydrocarbon vapour, and pure graphitic carbon is deposited upon the surface of the filament. If the latter is uniform the deposit occurs equally over all portions. If, however, the electrical resistance is abnormally large in some portions, a greater temperature results in those portions, due to the increased expenditure of energy at these points, and a larger deposit of carbon occurs there, the filament becoming more uniform.

Although the process of flashing was originally introduced to make the filaments uniform, it is not necessary to resort to it at present for that purpose. It is still employed, however, because it makes the filament stronger and more efficient. It makes the filament stronger for the reason that the deposited graphitic carbon is more compact than the amorphous carbon of the filament proper. It is made more efficient because the grayish graphitic coating does not radiate heat as well as the black amorphous carbon. Consequently, with a given electric power supplied, the treated filament rises to a higher temperature than the untreated one, and gives out more light.

When the flashing of filaments was introduced the general method used was a step-by-step process, first treating, then measuring the resistance, treating and measuring until the proper resistance was obtained. At the present time the flashing process is automatically cut off at the moment when the filament resistance is correct. It is done under a partial vacuum, and the voltage used is about 40 per cent. above the normal value. The operation lasts about ten seconds, depending upon the size and kind of filament as well as upon the practice of the manufacturer. Since the resistance of the filament is generally reduced to less than 50 per cent. of its former value by the flashing process, it is necessary to automatically regulate the voltage during the process.

The glass work may be divided into two parts, the stem and the bulb. Since the filament is first attached to the stem and the latter is afterwards sealed into the bulb, we will consider the stem first. It is made up of the " flange " and the leading-in wires. The flange is made of lead glass of exactly the same com-

position as the glass from which the bulb is blown. It generally comes in tubes about 5 feet long, the size depending upon the ideas of the manufacturer. These tubes are placed on rollers, and flanges are run on both ends, the heat being furnished by gas burners. When a number of these lengths have been flanged, the ends are cut off to standard length, the process being repeated until the entire tube is used up (see Fig. 6).

The leading-in wires make the connection from the base to the filament. They are of copper, excepting that portion which is sealed into the glass, which is of platinum. Platinum must be used at this point to insure a perfectly tight seal, because platinum is the only available substance which has the same coefficient of expansion as glass. Other materials have been tried, but either the glass cracked upon cooling, or the material would contract more rapidly than the glass, and a leak was the result in either case.

Having been fused to the copper leading-in wires, the platinum tips are passed through the flange until they just protrude beyond the unflanged end. This end of the flange is heated and pinched together over the platinum tips, being worked and blown until perfectly air-tight and symmetrical. The platinum tips are finally passed through the gas flame to burn off any impurities which may have been deposited upon them. The stem is carefully annealed, and is inspected for leaks and bubbles. It then goes to the mounter, who connects the filament to the platinum leading-in wires by means of a special carbon paste. After the filaments have been attached they are placed in an oven and fired for about fifteen minutes at a temperature of 400° F. This is for the purpose of thoroughly baking the paste and making a perfect joint. They are next sent to the straightener, who carefully adjusts the filaments to a standard form before they are placed in the bulbs.

Only one-third of the glass in a pot is used by the best bulb makers for their purpose. The remainder is dross, not being sufficiently transparent, and is made up into dishes and other articles. It is largely for this reason that lamp manufacturers do not make their own bulbs. The bulbs, as they come from the glass works, have long necks, as shown in Fig. 5. They are first thoroughly cleaned and are then fitted with a glass tube at the top, through which the air is eventually exhausted. The "tubulated" bulb is then sent to the sealer, where the stems, with the carbons mounted upon them, are sealed into the bulbs. This work is frequently done by machinery, and there seems to be a question as to whether machine or hand-work is the better. The former has the advantage of costing less, but it is claimed that the hand-work is the more perfect, as it is constantly under the control of the operator, who must necessarily be skillful.

In sealing the stems into the bulbs the first process is known as "pulling"

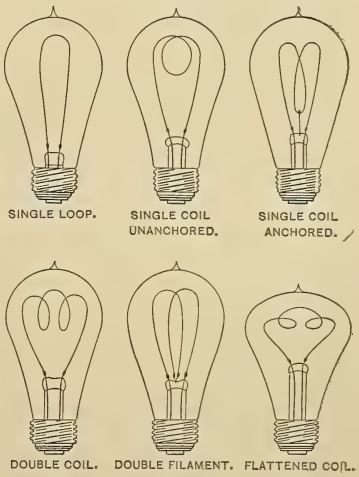


FIG. 8.—TYPES OF FILAMENT

the bulbs. This consists in melting off the long neck at the proper point to form a seal where it can be covered by the base of the lamp. Then the stem is inserted into the bulb, the flange on the stem being approximately the same size as the neck of the bulb, and the

sealing is done by fusing the glass at the joint in the flame of a gas burner. After perfect fusing, the bulb is blown from the tubulating tube to give the sealed portion of the stem a uniform thickness. The stem is then carefully centered by the operator and a small indentation is made in each side of the

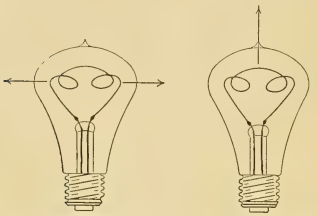


FIG. 9.—CANDLE-POWER MEASUREMENTS

neck so that the base may be securely attached with plaster.

Having been sealed, the lamps are carefully inspected and tested for leaks. This test is made with a simple air pump and a tub of water, the air being forced through the tubulating tube into the lamp. Bubbles will appear in the water if a leak of any size is in the bulb. The lamps then go to the "painter," who, by air pressure, forces a liquid containing phosphorus into the tubulating tube to a point within about 1 inch of the place where the tip is afterwards made. Upon removing the air pressure some of this liquid remains as a coating in the tube. After the paint has dried the lamps go to the "pumper."

The present method of exhaustion is what is known as the chemical exhaust. It is accomplished by means of small fly-wheel, two-cylinder vacuum pumps. Each pump is attached to a yoke upon which there is provision for two lamps. Each lamp is first thoroughly warmed in a small oven with which each pump is provided. The tubulating tube is connected to a heavy rubber tube which leads to one side of the yoke. The vacuum is then "turned on" and the exhausting process begins. The operator attaches the leading-in wires to a holder above, and the current is turned on at a low voltage, the lamp being pumped at the same time.

The operator then places the second lamp in the other side of the yoke and connects it for the current. By the time the second lamp is ready the first lamp should have a sufficently high degree of vacuum to stand treatment. This consists in raising the voltage about 50 per cent. above the normal, and to a point where a blue glow covers the entire inner surface of the bulb. The burning of the lamp during the exhausting process is to drive out occluded gases and also to test the filament. When the blue glow shows clearly, the pump is shut off, and is turned on the second lamp, which is being exhausted while the first lamp is being completed. By the heat of the gas jet a sufficient quantity of the paint is evaporated to cause the blue glow to suddenly disappear. Immediately after this the current is reduced and the lamp is sealed off at the tip.

The exhaustion of the lamp by this process requires the closest attention of the operator, for a trifle too much paint evaporated means yellow lamps, a trifle too high burning means blackened carbons, and a trifle too little burning means insufficient vacuum. By this method the lamp is not exhausted to so high a degree of vacuum as is possible by the old mercurial process, but the gas, which is generated by the evaporation of the paint, renders innocuous the gases yet remaining in the lamp.

After the lamps have been pumped they are at once tested for vacuum by means of an induction coil, and are also inspected for yellow or blackened bulbs. They are then sent to the photometer rooms and tested for candle-power.

Although the greatest care is taken throughout, it is impossible for a manufacturer to produce absolutely uniform lamps. Suppose he desires to produce a lamp which gives 16 candle-power at 110 volts! Probably not more than 30 per cent. can be properly rated at exactly the desired voltage. The other 70 per cent. may require anywhere from

104 to 116 volts to produce 16 candle-power, some being less and some greater than 110-volt lamps.

In the photometer rooms the lamps are all measured for voltage at the proper candle-power. The method consists of comparison with a standard incandescent lamp, adjusting the voltage at the lamp under test until the proper candle-power is obtained. The correct voltage is then marked on the lamp, as is also the electrical power taken at this voltage.

The lamps are next taken to the stock room and placed in trays or bins, being classified according to candle-power, voltage, and electrical power taken. The greater portion of the stock is kept in this way, although that from which immediate shipments are made consists of the completed lamps. The principal season for this, aside from the financial one of keeping the capital invested in stock as low as possible, is that the manufacturer cannot foresee exactly what style of lamp base is going to be most in demand. Quite a number of bases have been in use, although at present the Edison and Thomson-Houston (T-H) bases are more standard than any others. Most lighting companies use one kind of socket only, and so order all lamps of the same base. However, a lamp company must be ready to supply orders for any base desired.

As the shipping stock in any one base becomes low, the lamps are taken from the general stock room and are once more tested for vacuum. They are then sent to the "cappers," where the bases are attached to the lamps with plaster and the leading-in wires are placed in position. When the plaster has become sufficiently dried, the leading-in wires are attached to the bases with solder. The lamps are next burned once more, to be certain that the connections are perfect, and that the bases will make

FIG. 10.—PROVIDING THE LAMP BULBS WITH BASES

good contact in the sockets. They are then sent to the finishing room, where they are thoroughly cleaned and labelled, showing the correct voltage and candle-power. They are finally wrapped in tissue paper and packed in barrels or boxes for shipment.

The recent developments in incandescent lamps have not been very startling, being principally in the reduction of cost, improvements in the shape of filaments for better light distribution, and general improvements in manufacture which have resulted in the production of lamps of greater efficiency and longer life. The cost of lamps has also been cut down greatly, due to improved methods of manufacture.

A variety of types of lamp filaments is in use by the various manufacturers. Lamps of high candle-power generally have a hairpin filament with no loop or coil, as filaments for such lamps are necessarily short and heavy. With the introduction of the higher voltage and lower candle-power lamps came departures from the simple form, and we see filaments with a single coil, both anchored and unanchored, with double coils, double filaments, and flattened coils (see Fig. 8).

There is a considerable difference in the way in which the various filaments distribute light. According to the ordinary methods of measurement, a 16-candle-power lamp is one which gives this candle-power in a horizontal plane when the lamp is placed in a perpendicular position. Because of this method of measurement lamps generally give their rated candle-power in this direction. There is much difference, however, in the candle-power emitted in other directions, especially in those through and near the tip of the lamp. The flattened coil filament has been especially designed to increase the light emitted in these directions.

With 16 "horizontal" candle-power, this type of filament will give about 12 "end-on" candle-power, while the others vary from this value down to about 5 end-on candle-power. Since probably 90 per cent. of the incandescent lamps now in use, aside from those used for decorative purposes, are either placed with the tip vertically downward or within 45° of this position, the question of end-on candle-power becomes one of importance, so much so that many lighting companies require manufacturers to guarantee certain end-on as well as a certain horizontal candle-power.

The useful life of a lamp is now considered to be the number of hours of actual burning at normal voltage before the candle-power falls 20 per cent. of its initial value. Thus the useful life of a lamp giving 16 candle-power is the number of hours it will burn before its candle-power falls to 12.8 candle-power. Good 110-volt lamps of average efficiency should have a useful life of from 500 to 600 hours.

It is difficult to foresee what the future has in store for the incandescent lamp. Many are of the opinion that its days are numbered, and that it will soon be replaced by the Nernst lamp or some form of vapour lamp. Others believe that there is room for all these forms of electric lamps, and that the use of the incandescent lamp will increase as rapidly in the next ten years as it has in the past decade.

HOISTING MACHINERY

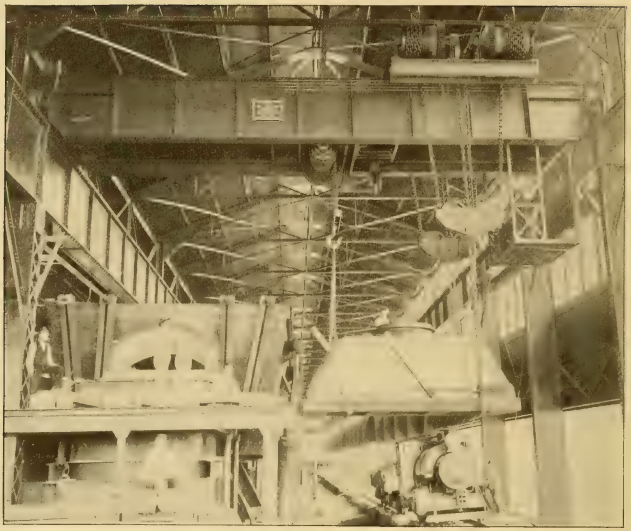
ITS INCREASING IMPORTANCE AND DEVELOPMENT

By Joseph Horner

DURING the last ten or dozen years immense developments have taken place in hoisting machinery, and there has been a notable increase in the power, handiness, and variety of apparatus of this kind. Cranes are made now of a weight, lifting capacity, range of movement, and mobility such as would scarcely have been dreamed of a few years since. The light cranes as well as the massive ones have developed. In the older shops the call often rang out:—"Now, chaps, lend a hand here, heave ho"; and gangs of labourers stood at attention, and ate up profit, although their wages were low. The alternatives were the slow-moving, differential pulley blocks, or the lumbering hand-crane or traveller, which took so long to get on the job that except for the heaviest masses, the united power of several labourers was quicker in operation.

A dozen years ago there were practically no electrical cranes in Great Britain, and no transporters, no air hoists. The hand and the steam cranes predominated; hydraulic cranes were not numerous. Hand cranes occupied the largest place. Many machines for lifting loads ranging in weight as high as forty tons have been made to be operated by hand. Some of these, when dealing with maximum loads, required six or eight men at the winch handles, working in cramped positions, and lifting the load through double or treble gear much more slowly than the slowest speed of a modern power crane. The methods of loading and discharge of cargo and of coal to and from vessels were mostly cumbrous and slow in action, often consisting only of fixed hand, or steam, or hydraulic wharf cranes of common types; and work that takes an hour now occupied a day then. Employers thought less of paying the wages of a gang of labourers wheeling barrows than of investing a few hundreds in rapid hoisting, loading, and discharging machinery.

Nothing has given such an impetus to crane design in recent years as the electrical conductor. The introduction of the electric motor into crane work has modified designs in several ways. Thus, it has displaced altogether, or simplified, the numerous older devices for operating the three movements of an overhead traveller from one source of motion, by supplying three, or four separate motors, each suitably adjusted to its own particular duty. In place of clumsy square shafts, and of steam and water pipes, it has given us the conductor of ¼-inch or ½-inch diameter, from which the crane can take its motive power at any location. It has also brought a new lease of life to the worm gear, inasmuch as there is no method so neat as this by which high motor speeds can be reduced to the lower speeds required for travelling and hoisting. It has had the effect of introducing the treble-threaded worm into general practice, and with it the necessary enclosed bath of oil to diminish friction. It has rendered necessary a higher standard of workmanship, due to the high speeds and the delicacy of the elec-



A 40-TON LADLE CRANE AT THE WORKS OF THE CARNEGIE STEEL CO., LTD., PITTSBURGH. BUILT BY THE BROWN HOISTING MACHINERY COMPANY, CLEVELAND, OHIO, U. S. A.

tric motors. Some complication has been introduced by the necessary controllers with their resistances, but this is not really so great as that of the displaced steam boiler and its fittings, or the mass of gears and clutches necessary on ordinary cranes, while there is an immense gain in cleanliness.

The growth of the electric traveller is remarkable from whatever point of view it is regarded, for within a dozen years it has been evolved into a very beautiful machine with comparatively little assistance from the electricians; and now it embodies a design very unlike that which engineers and electricians first adopted, and which was for some time deemed the only type practicable and workable. It is now the leading specialty of several firms in Great Britain, and America, and on the Continent. It has been and is still being installed in numbers of shops. One fact which has contributed to its rapid growth is that the electric plant used for lighting and machine driving of shops can also be used for crane driving. But apart from that, the abolition of square shafts, of engines, boilers, cotton ropes, and the advantages just now named ensured its rapid growth.

The auxiliary hoist for light loads driven by its own motor has, during three or four years past, become a valuable adjunct to the electric traveller, in economising both power and time in foundry and machine shop. A forty-ton steel ladle crane of the overhead traveller type for the Carnegie Steel Company made by the Brown Hoisting Machinery Company has the auxiliary hoist fitted in this case for tipping the ladle. The load of forty tons is lifted on four drums on the main trolley by an eight-part chain, and the auxiliary hoist of ten tons power is placed on a trolley that runs between the girders.

The harbour type of gantry crane has received its chief development since the application of electricity to crane driving. Cranes of this type were made many years ago,—steam-driven, with the boiler on the crane itself. But about ten years ago some Continental

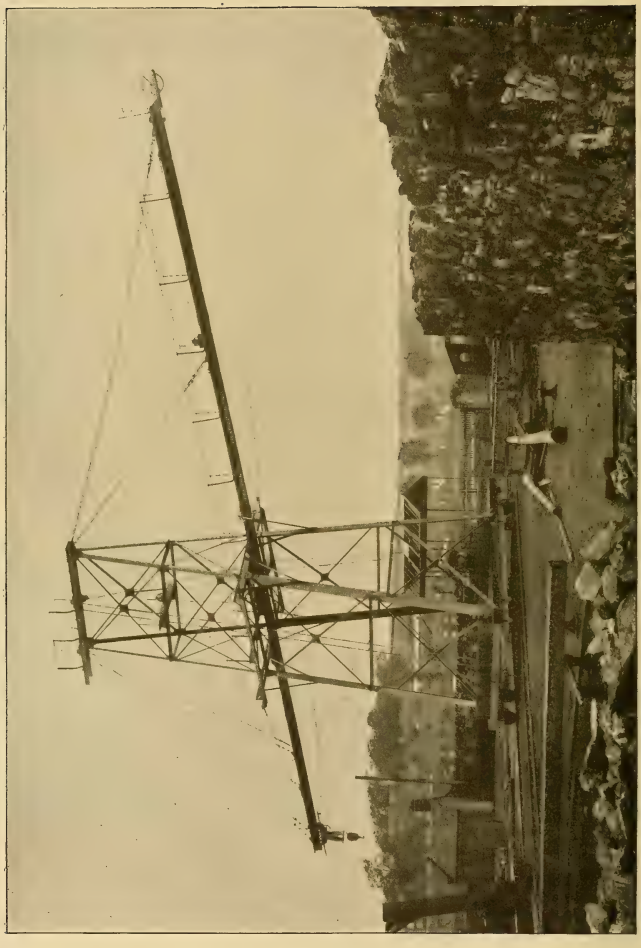
firms substituted the motor drive with great success, since which time many hundreds of these cranes have been made for Continental ports.

The cotton rope cranes are excellent hoisting machines which would have been much more extensively employed than they are to-day but for the rivalry of the electric type. These two between them have displaced, to a great extent, the square shaft and the hand cranes which previously divided the field among themselves. What sensible man would now think of putting up a square-shaft drive in a new shop? Yet it was common practice only ten years since.

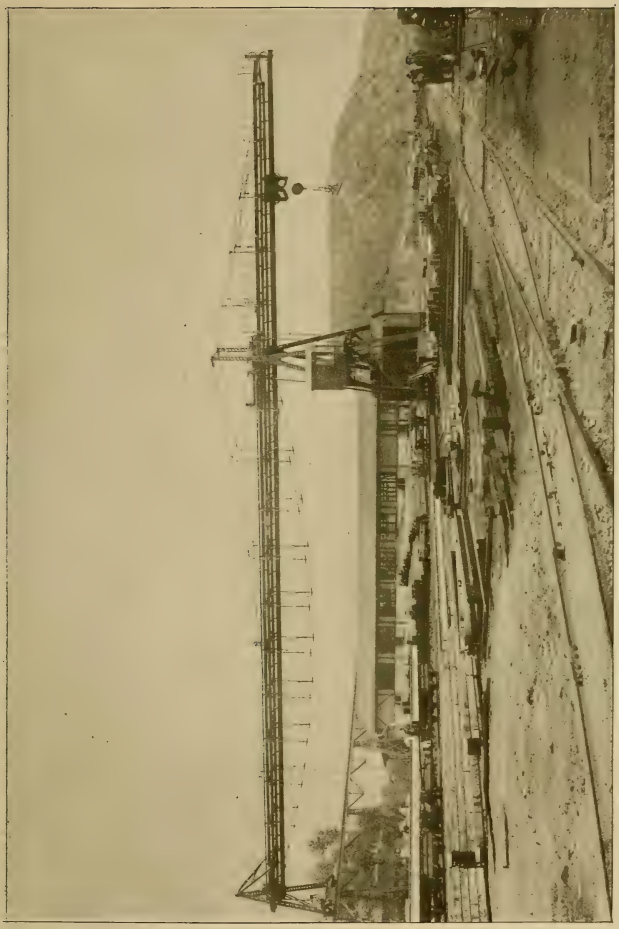
The very remarkable developments of certain cranes of exceptionally long range and mobility during recent years illustrates the high importance with which this branch of engineers' work is now regarded. The Temperley and the Brown are both long-armed, high-speed cranes, less known in Great Britain than in the United States and other countries, and their future potentialities are not yet generally appreciated in the United Kingdom.

The range and mobility of these hoisting machines are remarkable. In the bridge tramways of the Brown Hoisting Machinery Company the material is hoisted and carried by the trolley a distance of 300 feet,—more in some cases,—dumped, and the trolley is run back over the same distance within a minute! The design, too, is such that the ground is covered by very narrow tracks, only one of the legs or "piers" on which the machine is carried being double, with double sets of wheels. The total length, moreover, of the bridge, 300 or 330 feet, is divided between three sets of girders. There is the "span" of the crane, which is either 180 or 192 feet in the standard sizes, supported by the travelling piers; the cantilever to the rear,—from 80 to 104 long feet,—and the "apron," of 34 feet, over the vessel or trucks. The apron is hinged, so that when in service it can be inclined to suit the depth from which loading or unloading has to be done, and when not in service it is lifted up into a vertical position, to leave the way unobstructed for the masts of vessels. Also the great length of span and the free fitting of the

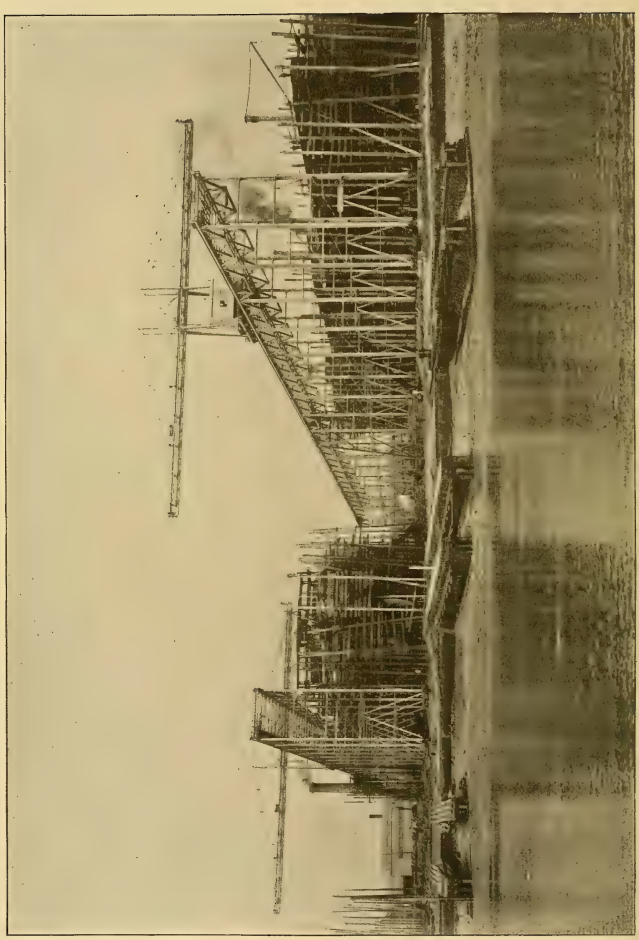
AN ELECTRIC BRIDGE CRANE AT A BELGIAN QUARRY. IT LIFTS 40 TONS AND WEIGHS 170 TONS. BUILT BY THE INTERNATIONAL ELECTRICAL ENGINEERING CO., LIEGE, BELGIUM, AND LONDON



A TEMPERLEY TRANSPORTER ON A TOWER OF 14 FEET GAUGE. THE ARM IS 97 FEET LONG. THE MOTIVE POWER IS ELECTRICITY. BUILT BY THE TEMPERLEY TRANSPORTER CO., LONDON. IN THE UNITED STATES THE TEMPERLEY TRANSPORTER IS BUILT BY THE LIDGERWOOD MFG. CO., OF NEW YORK



A FOUR-TON BRIDGE CRANE BUILT BY THE BROWN HOISTING MACHINERY CO., OF CLEVELAND, OHIO, FOR THE WITKOWITZER BERGBAU UND EISENHUETTEN GEWERKSCHAFT, WITKOWITZ, AUSTRIA



TWO 15-TON BROWN CRANES ERECTED BETWEEN LAUNCHING WAYS AT THE SHIPYARDS OF MESSRS. VICKERS, SONS & MAXIM, LTD., BARROW-IN-FURNESS

girders to the piers permit the front piers to be adjusted sideways to a limited extent to allow the hinged apron to be accommodated to the hatches of vessels. Yet again, instead of a separate boiler and attendant being required for each machine, one boiler and engine and one attendant suffice for three or four bridge tramways. An operator is required for the movements of each bridge. Then there is no reversal of

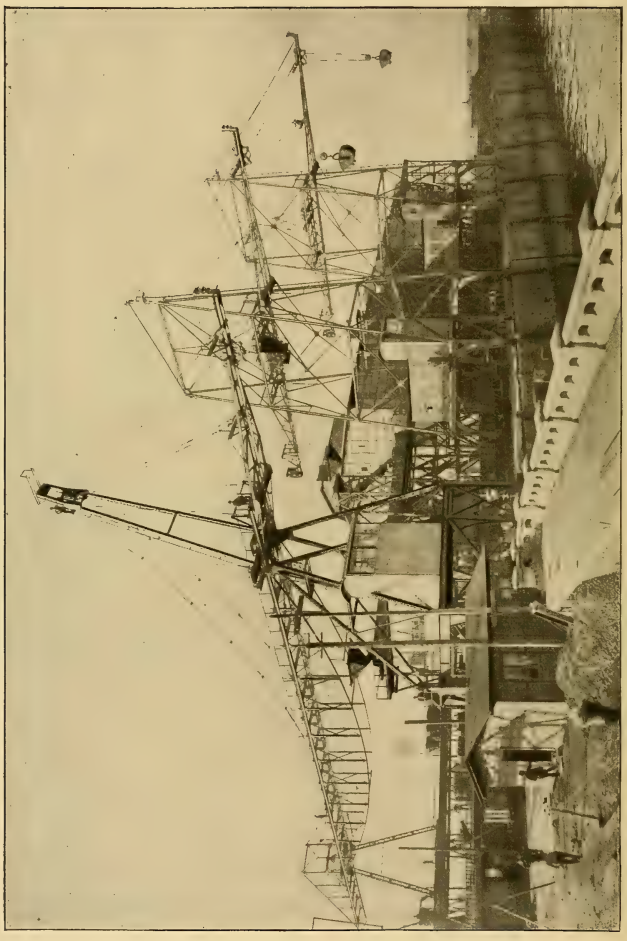
A TEMPERLEY TRANSPORTER DISCHARGING COAL FROM RAILWAY WAGGONS AND STORING IT UNDER COVER

engines. They run in one direction, and reversal is effected by a friction clutch.

The cost of handling material with these cranes is remarkably low. As an average from the practice of several firms in the United States equipped with these machines it is given at from seven-tenths of a cent to two cents per gross ton, the difference depending largely upon the despatch exercised by the shovellers. Even this is avoided in many cases when grabs and automatic shovel buckets deal with coal and ore.

Loads are often weighed in transit, and a single bridge crane is capable of handling from 40 to 45 tons per hour under average conditions. In the Lake Superior district the iron ore shipments, which cost about a dollar and a quarter for freight per gross ton before the Brown cranes were installed, are now reduced to sixty cents.

But besides the types of Brown cranes which dump or carry from a storage heap on dock or railway side, there are plants where no storage is used, but in which the railway cars are loaded on several adjacent railway tracks direct at once. Sometimes two, five, or even seven tracks are covered at once, and fifty cars are being loaded under the cranes at one time. The full cars are made up into trains and replaced with empties, but the loading goes on incessantly, because a supply of empty cars is kept on some of the various tracks. The speed, too, is higher than that of the storage plants; one of these fast



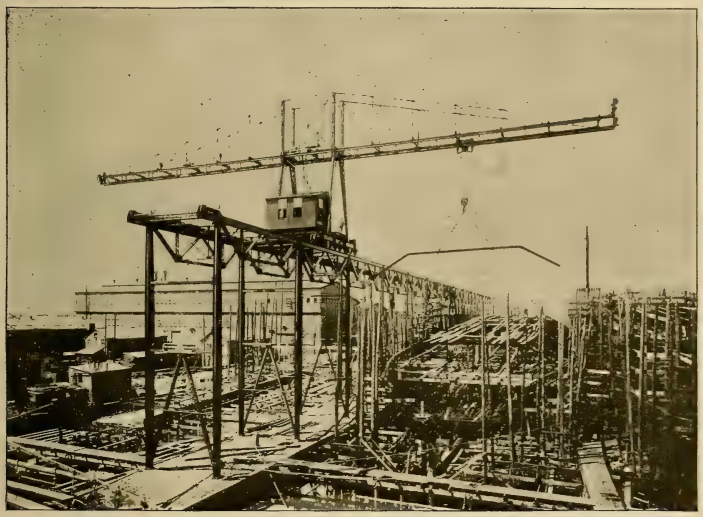
THREE ELECTRIC LOADING CRANES BUILT FOR THE NORTH GERMAN COAL AND COKE CO. AT HAMBURG, BY MESSRS. ADOLF BLEICHERT & CO., LEIPZIG-GOHLIS, GERMANY. EACH CRANE HANDLES OVER 600 TONS OF COAL IN TEN HOURS

cranes, for example, lifts its full load of five tons at the rate of 200 feet per minute, and carries it along at 1000 feet per minute.

The successful competition in the American steel trade owes something to the Brown hoisting machinery. The Brown shovel, operated by a Brown bridge crane, picks up five tons of ore at a scoop from a storage pile and drops it into bins under the cantilevers, whence

connected by ropes to the trolley. This can be manipulated to obtain a double purchase. These cranes travel down their tracks with cantilevers rigidly fixed to their piers, or the superstructure is made to revolve on the pier. In this they hold a record for long radius, a double-armed crane revolving through a circle 300 feet across.

It seems singular that so long a period elapsed before the double-armed Brown

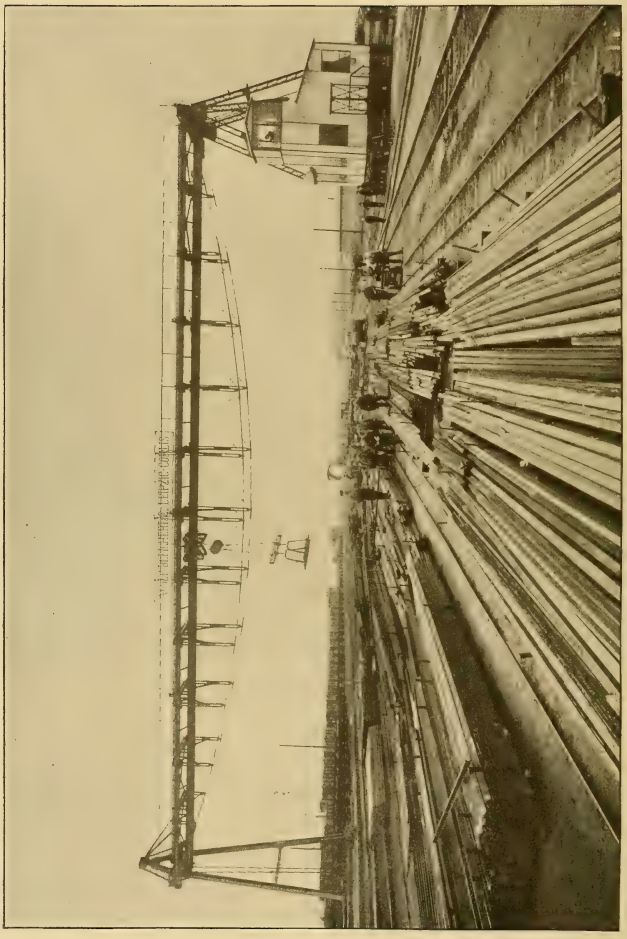


A 15-TON BROWN CRANE AT THE CRAMP SHIPYARD, AT PHILADELPHIA

it is drawn into the furnace-charging waggon of the furnace hoist. A single bridge crane, operated by one man, will thus handle from 1500 to 2000 tons in a day of ten hours, or will store from 2000 to 3000 tons in the same time. Coal storage is handled similarly. A car dumping machine and two cranes would load 10,000 tons in ten hours.

The Brown "balanced cantilever cranes" comprise two cantilevers standing out on each side of the "pier" or central standard. The trolley which runs along the cantilevers is counterweighted automatically by a weight running on a track on the bridge, and

crane was invented. The germ of the idea is in the balance crane. But instead of tons of useless ballast, the Brown crane provides two useful balanced working arms of equal length on each side of the carriage. That permits of lifting at any radius without the complication and risk of slewing maximum loads on a balance crane. Unsteadiness, due to the varying radius of the trolley and its load, is provided against by the counterweight, which is so connected with ropes to the trolley that it automatically occupies a position on one arm at the same radius as the load on the other. The width of the wheel base



ELECTRIC LOADING CRANE, OR TRANSPORTER, IN THE YARD OF THE PEINE, HANNOVER, GERMANY, ROLLING MILLS. BUILT BY MESSRS. ADOLF BLEICHERT & CO., LEIPZIG-GOHLIS, GERMANY. SPAN, 1146 FEET; LIFTING CAPACITY, 8 TONS

affords ample stability under maximum loads, and it is remarkable to observe how very steadily the whole crane travels at the high speeds of several hundred feet a minute. In ordinary gantry cranes, the girders of which are often built of solid plates, the wind pressure is considerable, and in exposed, storm-swept districts it is liable to blow the crane over. The enormous cantilever beams of the Brown cranes are built and braced so lightly that this danger is reduced to a minimum, and this is practicable because there is no heavy crab running along the track, but only a light trolley.

The old system, due to the steam-driven travelling crane, of putting the motive power and gears on the crab has been a bar to a better design. A crab so loaded is very heavy, and produces three evils, namely, the excessive power required to operate it, the difficulty of stopping quickly when momentum has been acquired, and the excessive dead load which has to be carried by the bridge beams in addition to the load. In the new types of cantilever cranes this has been avoided. The crab motions are supplied by wire rope, driven from an engine or electric motor situated in the base of the pier or tower, just where weight is wanted. The bridge girders have practically nothing to carry but their own dead weight and the load lifted. Hence, though of immense length, or span, they are spider-like structures that offer little surface to wind pressure.

The applications of these cranes are numerous and varied. One of the most valuable is to be found in shipbuilding, since one crane will cover two adjacent launching ways between which it travels. In one installation three cranes cover six ships; in another four cranes are designed to cover eight slipways.

At Barrow the writer recently saw a fine installation of Brown cranes. The large plate storeyard is covered by a five-ton, double-armed crane with a maximum span of 318 feet from centre to centre of the hoisting block, which, with the combined travelling movement of the framework and traverse of the trolley, covered every inch of the yard. An 85 H. P. motor lifts the maximum load at the rate of 200 feet a minute, traverses the trolley at any speed up to 750 feet per minute, and travels the crane along its tracks at about 300 feet per minute. Then down at the shipbuilding ways two Brown cranes serve four ships.

The illustration of these on page 252 gives an excellent idea of the value of the type in shipbuilding. These are fifteen-ton cranes, duplicates of similar ones which the firm has built for the Cramp Company, of Philadelphia, and the Newport News Company, in Virginia. Each crane covers two building slips, lifts fifteen tons at a distance of 65 feet on each side of the centre, and seven tons at 90 feet. The full load is lifted at 200 feet per minute; light loads are lifted at 400 feet. The trolley travel is from 400 to 600 feet, and the travel of the crane on the trestles is from 700 to 750 feet. The shipbuilders owe much to the introduction of these types of cranes. Generally tall goliaths, or travelling gantries, or overhead travellers are employed. The goliaths used first on the White Star Line steamer *Oceanic* at Belfast made a record departure in height and span, as have the Brown cranes in a different design. The huge gantry which spanned the *Oceanic*, made by Messrs. Fielding & Platt, Ltd., of Gloucester, England, gives 98 feet clear in height and 95 feet in width, and carries several cranes and riveting machines.

In connection with this it may be observed that the practice of hydraulic riveting has had the result of bringing into much importance certain types of hydraulic cranes which for this class of work hold a monopoly in favour, since the riveters and the cranes can be most economically operated by the same agent, besides which the perfect control under which such cranes are maintained is a great point in their favour as regards the setting of the riveters in position.

The jibs of the Temperley transporters are attached to temporary or permanent masts or towers, and the auto-

matic trolleys transport and discharge light loads at high speeds. An interesting recent coal conveying plant operated by Temperley transporters is seen on page 253. The travelling tower carries two short beams and two sets of machinery. The beams are brought opposite and attached to any two of the twelve beams that are carried from the roof of the shed along which the coal is transported and dumped automatically in any position required.

The manufacture of high speed cranes is also undertaken successfully in Germany. The illustration on page 254 shows three electrically-driven loading cranes for the North German Coal and Coke Company, of Hamburg, each one handling over 600 tons of coal in ten hours, while on page 256 is shown a transporter in the storeyard of the Peine, Hannover, Rolling Mills. This last has a span of about 148 feet and very high working speeds. These outfits have been built by Messrs. Adolf Bleichert & Co., of Leipzig-Gohlis, who are well known in connection with the Bleichert ropeways.

The concluding portion of this article, to appear in the February number of this magazine, will deal with hydraulic wharf cranes, portable steam and electric jib cranes, locomotive cranes, and hoists and winches for general service.

ENGINEERS IN THE UNITED STATES NAVY

THE PRACTICAL WORKING OF THE LINE AND STAFF AMALGAMATION PLAN

By Admiral George W. Melville, U. S. N.

Admiral Melville's recently issued annual report as chief of the Bureau of Steam Engineering of the United States Navy contains an interesting section devoted to the working of the amalgamation plan for officers of the Line and Staff which was carried into practice a few years ago. Thus far the scheme, which is the outcome of the "Naval Personnel Bill," designed to bring about an alternation of duties, above decks and below, of naval officers, and practically wipe out Line and Staff distinctions, has resulted in failure, and the reasons for this, how to avoid them, and an outline of how to secure the better efficiency below the protective decks of modern ships of war originally aimed at, are set forth in the report as here repeated.

In Great Britain the outcome of the scheme has been watched with almost, if not quite, as much interest as in the United States, as the lot of the engineer in the British Navy has been similar in many respects to that of his American confrère, and re-organisation measures of some kind have been fully as much in demand.—THE EDITOR.

EVER since the passage of the personnel bill I have contended that the measure of success to be secured from the law would be altogether dependent upon the manner in which it was interpreted. It was certainly the expectation of Congress, and also of the personnel board, that the status of engineering in the Navy would be advanced by this law. In fact, the controlling influence which made possible the passage of the bill was expressed by the then Assistant Secretary Roosevelt when he stated that "Every officer on a modern war vessel has to be a fighting engineer." This statement so succinctly stated the fact that it received the widest approval as soon as it was published. The reason for its ready acceptance was because thoughtful men had for a considerable time previous recognised the present as an age of engineering. Particularly in respect to naval matters had the public at large come to the conclusion that the modern battleship is a floating fort filled with complex machines, whose efficient care and maintenance can be intrusted only to a trained mechanical force, and the best efforts of this force can be obtained only when directed by trained officers. This applies to every department of the ship, and is only more applicable to the engineer department be-

cause that department comprises not only the most important, but the greatest number of mechanical appliances.

I am simply stating a fact when I assert that the number of trained and expert engineers in the Navy is being steadily reduced. The practical working of the amalgamation scheme thus far has been, in great part, to take the junior half of the old Engineer Corps and transfer them to line duties. Individual officers of the old line have conscientiously striven to perfect themselves in engineering duties, but up to the present time no systematic measures have been taken to train officers for the engineering needs of the future. The work is too important and the needs of the future too great to depend upon individual effort to secure sufficiently numerous and trained officers for such duties. Herein has been the radical weakness of the system that has been pursued since the passage of the bill.

The failure to establish systematic methods for maintaining engineering efficiency was anticipated by earnest friends of the Navy during the discussions attendant on the passage of the personnel bill. When the subject was being investigated, the question was raised of how officers trained in engineering duties were to be obtained under the amalgamation scheme. The positive assurance was given that this was provided for by alternation of duty between deck and engine room. The point was then raised, Why should it not be specifically stated in the bill that this alternation must take place? The answer to such question was that this was a detail which could best be carried out by departmental order or regulation. The sincere advocates of the measure believed that it would not be best to limit the Department by specific operation of law. As the proposition was one which had been indorsed by the Secretary, and even commended by the President, it was presumed that the whole influence of the Navy Department would be exerted in improving the status of engineering. It was certainly expected by the naval committees of the House and Senate that the Department, by regulation, would provide for the engineering needs of the future; otherwise this need would have been carefully taken into consideration in the framing of the measure.

It may be urged that the work of the Navy has greatly increased since the passage of the personnel bill, and that there has been an inadequate number of officers available for all kinds of duty.

This is a fact; but for every three commissioned officers taken from the engine room and transferred to deck only one commissioned officer from deck has been sent below. This does not completely describe the extent of the depletion in the engine-room supervision. The officers sent from the engine rooms were transferred to the deck for permanent duty, while in most cases the junior officers transferred from the deck have done engine-room duty only for short periods. In explanation, it has been stated that 100 warrant machinists have been appointed and detailed for engine-room duty. It must be remembered that all these warrant machinists came from the enlisted force of the engine rooms and had very little experience in handling large bodies of men. Without detracting, therefore, from the merits and capabilities of the warrant machinists, they are not altogether fitted by previous training or experience to take charge of an important department of the ship. Their successors, in many instances, were petty officers whose experience at sea was very limited. The gain in the engine rooms from this source has thus been more apparent than real. If, however, warrant machinists are competent for such duty, it may be pertinent to inquire why the boatswains and gunners, who are also warrant officers, are not equally competent to carry on the routine deck duty. Such an arrangement would permit some of the junior officers of the line to receive engineering instruction, even if it were not deemed desirable that they should render service beneath the protective deck. In the British service boatswains and gunners carry on such deck duty on small ships, and it is to be presumed that American

warrant officers would also be competent for the task if such assignments were made.

As a result of this inadequate supervision in the engine rooms there has been a perceptible decrease in the efficiency of the machinery and a progressive increase in the cost of repairs. Definite data upon this question are difficult to secure, since this retrogression is progressive in character, and the full extent of the evil cannot be determined without searching investigation. The condition of the machinery of the torpedo-boat flotilla shows the trend of affairs.

During the past year the disablement of torpedo-boats has been of such frequent occurrence that the majority of the boats have been under repair a great part of the time. Many of these mishaps are serious in character, and the present condition of the flotilla affords an incontrovertible argument in favour of the proposition that practical engineering ability of high order is required for their successful care and operation. In my opinion, the machinery of the torpedo-boat craft would not be in its present deplorable condition if engineer officers of experience had been detailed for supervisory duty in connection with the boats.

It is strikingly significant that the decrease in machinery efficiency has been most marked in the case of the torpedo-boats. With this type of craft it has been attempted to practically maintain the machinery in operation without the supervision of trained engineer officers. With such a system in operation it is not surprising that inefficiency should be the rule. Upon official trials the builders of such boats find it necessary to fill the engine rooms with supervising engineers of ability and experience, who command high salaries. After such boats are turned over to the government it cannot be expected that an insufficient and unskilled force will be capable of operating them. The depreciation of the boats will take place at a rapid rate if either an inadequate or inefficient personnel is to be intrusted with their care and maintenance.

That efficiency beneath the protective deck is no less important in naval warfare than efficiency above it cannot be doubted. The boiler plant is the heart of the vessel, and any weakness in that direction will be followed by general decline everywhere else. The difference between an efficient and inefficient force on board a warship was shown at the battle of Santiago. The crowning act of that victory was the overtaking of the *Colon* by the *Oregon*. In this chase a battleship of 16 knots speed, manned by an efficient engine-room force, overtook a 20-knot armoured cruiser whose motive power was inefficently handled, since only about one-half the boiler power was developed on board the *Colon* that could have been secured by a skilled force of mechanics and firemen directed by a trained and educated complement of engineer officers.

The bureau has reason to eventually expect efficient service from the young line officers sent to engineering duty if such junior officers are made to understand that promotion awaits only those who qualify in this direction. The greatest good that must come from such details will be manifest in the future.

It cannot be expected that immediate results will be secured from this change in the future engineering training of the naval personnel. Satisfactory progress can be secured only by development. The experience of the cadet engineer system, whose abolishment cannot be too deeply regretted, showed that a perfected system of training engineer officers could be secured only by progressive experience and observation. Although the system was established at the Naval Academy in 1866, it was fifteen years from that time before a satisfactory course of instruction had been outlined that was in keeping with the needs of the service. It will require time also to perfect the present system.

As the paramount purpose of these details must be to secure an engineering personnel for the future, I strongly advise that a large contingent of the junior officers be sent to the various navy

yards and to other stations where engineering instruction and experience can be secured. These junior officers should be detailed for engineering work exclusively. If additional duty is assigned by other bureaus, it cannot be expected that competent officers for engineering work can be adequately trained. This is not a question of specialising along engineering lines. It is rather a question of preventing inefficiency and demoralisation existing in the future. Those undertaking this work must be impressed with the fact that there are unpleasant as well as attractive features in qualifying along every line of work. Any system of training which will permit the unattractive and difficult features to be avoided will make for future inefficiency.

When the personnel law went into effect the United States had an engineering corps that was recognised as the equal, if not the superior, of that possessed by any other naval power. This efficiency had been secured because the junior officers of the old Engineer Corps had been taught the lesson that to attain success much disagreeable work had to be done and many unpleasant duties performed. Those who are to succeed to the duties of the old engineer officers must be taught the same lesson of interesting themselves in the difficult as well as the attractive work of the profession. The deep-seated prejudice that existed in the Navy against engineering duties has not altogether been eradicated, and from this cause it will be a difficult matter to create the interest and enthusiasm in this work that can be secured from more congenial and conspicuous assignments. It may not require much persuasion to induce many junior officers to acquire a superficial knowledge of engineering principles. It will need determined action, however, to compel a number sufficient for the engineering needs of the future to qualify to a degree that will make them proficiently capable of performing this important duty.

The success achieved in the past cannot be repeated unless the same pride and interest in engineering work are taken by those detailed in the future to this duty. The necessity for looking ahead being recognised, the practical problem arises as to what details of policy are essential for such success.

It has been said that the exposition of a military weakness can be justified only by suggesting remedial measures. In order to improve existing conditions, as well as to provide for engineering necessities of the future, the following recommendations are urged:—

1. That the policy lately inaugurated of detailing junior officers of the line exclusively to engineering duties be greatly extended.

2. That a post-graduate course of instruction in marine engineering and design be established at the Naval Academy for those junior officers of the line who desire to familiarise themselves with marine engineering.

3. That at least two war vessels be used in part for the general training of firemen.

In the British Navy the training of stokers is systematically carried on in the cruisers *Northumberland*, *Nelson*, and *Bellerophon*, vessels of 10,000, 7600 and 7500 tons, respectively. In these ships the stoker is taught that he has not only hands to use, but a mind to employ. After a course of instruction the recruit has a better chance of becoming, for naval purposes, not only a handy man, but a reasoning creature. Such an eminent authority as Lord Brassey recommends that the modern armoured cruisers *Powerful* and *Terrible*, ships of 14,000 tons displacement and 25,000 horse-power, be employed for the special training of the engine-room complements of British warships.

Fighting ships even are looked upon by the British Admiralty as desirable for the training of sailors. It has been officially announced by Lord Selborne that the squadron of training ships will not be resuscitated. Instead of developing the sailor lads on the royal yards, it is proposed that they be sent to sea in fighting cruisers. This significant action by the British Admiralty shows

the trend toward mechanical training for the entire ship's force.

4. That several torpedo-boats be kept in commission for the training and instruction of the machinists and water tenders of the torpedo-boat service.

5. An urgent necessity has arisen for the training for naval duties of the youthful and inexperienced machinists enlisted in inland cities. These young men can be induced to seek a life career in the Navy if some substantial recognition is accorded faithful, efficient, and continuous performance of duty. The number of chief machinists now in the Navy is simply inadequate for existing needs, and a sufficient complement can be secured only by giving the machinists, second class, a systematic and thorough course of instruction so as to make them familiar with the care, operation, and repair of the various auxiliaries used in the naval service. These auxiliaries include capstan, blower, and winch engines, evaporators and distillers; refrigerating, hydraulic, and pneumatic machinery; also the simple forms of electric motors. These machinists should be instructed as to the manner of making all kinds of joints used for high-pressure purposes, the method of packing various forms of stuffing boxes, and, in general, the manifold duties that must be performed in the engine department of a modern warship.

It would be extremely advisable to send all machinists, second class, to a navy yard for practical work on ships under repair for several months. The experience and knowledge that they would gain from this experience would make them more efficient for duty on board ship, and the Navy would be the gainer from having such men trained, in great part, at a navy yard where the diversity of work on repairs would develop all who had an aptitude for a naval career. If such a course of instruction be provided, it can be confidently predicted that the corps of warrant machinists can be recruited from this source alone.

As it is not probable that all the deserving machinists can from now on expect to secure warrant rank, I would urgently recommend that all machinists among the enlisted force who have served honourably for a period of twenty years be assigned to duty only at navy yards. There is much duty that these men could do at the naval stations, such as running tugs, taking charge of the steam fire-engines, looking out for the various boiler plants, and taking charge of the machinery of the ships in ordinary.

Under existing conditions, machinists remain only long enough in the service to fit themselves for taking positions in the merchant marine. They are lost to the naval service just when they are most efficient, and such a deplorable state of affairs should be remedied, if possible. I believe that the Department has only to offer some substantial reward in the form of permanent duty at a navy yard to induce many machinists to render twenty years' faithful service, and to look upon the Navy as a life career, and not as a temporary vocation which affords an opportunity for travel and sightseeing.

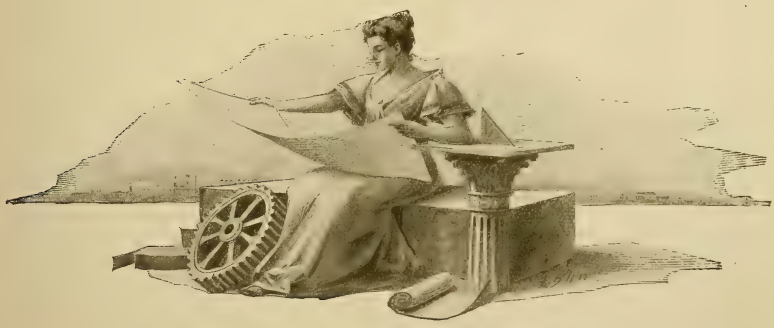
6. That the warrant machinists be placed upon the same footing as regards pay, and rank, and emoluments as given other warrant officers. In some respects the warrant machinists are discriminated against, and so long as this distinction exists they will have a grievance which must interfere with the efficiency of the engine-room force. Every avenue to promotion and increase of pay that is accorded other warrant officers should be given warrant machinists. The responsibility and character of the duty that rests upon this class of officers is as important as that devolving upon sailmakers, carpenters, boatswains, and gunners, and the opportunity for advancement should be equally as great.

7. That a special rate of pay be allowed those petty officers in the engine department who qualify as water tenders of torpedo-boats. Such a substantial reward is given those who qualify in certain deck duties, and the same inducement should be held out to the leading petty officers doing duty beneath the protective deck.

In connection with this subject of personnel there are features whose importance should be impressed upon the service at large. It is a certainty that the number of officers, doing engineering duty only, will diminish much more rapidly than is anticipated, and probably much sooner than is desired. By reason of the present interpretation of the personnel law the inducements for such officers to continue this work are very few. As attractive retirement features of the personnel law will soon be applicable to the majority of such engineer officers, it can be expected that the opportunities offered will be taken advantage of by many who are now doing engineering duty only.

It would also be well for thoughtful naval officers to compare our work in training an engineering personnel for the future with efforts that are being made by other naval powers. Is the engineering course at Annapolis comparable with that given the British engineering cadets at Keyham? Are we in advance or behind other nations in systematically training the petty officers and stokers of the engine-room force?

The warships of the future must be provided with a strong complement of commissioned engineer officers. The number and character of the enlisted force working beneath the protective deck, as well as the extent and complexity of the motive power, demand and require that there be detailed, for this supervision, a complement of educated officers possessing ability and high character. Either the junior officers of the line must be compelled to take up this work, or public sentiment will demand that the warrant officers be advanced to official positions commensurate with duties imposed upon them.



Current Topics

THE recent trials of the Gathmann guncotton shell, under the supervision of the United States ordnance department, against heavy Kruppised armour plate at the Sandy Hook Proving Grounds, are said to have resulted in failure to meet the expectations of its promoters. These shells were fired from an 18-inch rifled cannon especially made for the test in competition with service armour-piercing shot and shell from a 12-inch sea-coast rifle, the latter shells being charged with maximite and dunnite, a high explosive developed by the ordnance department, and the results were claimed to be a signal victory for the regular service high-explosive projectile. These trials were much mis-

reported in the daily newspapers, as one between the so-called Gathmann gun and the 12-inch sea-coast rifle, while as a matter of fact it was not a test between guns, for there is, strictly speaking, no Gathmann gun. The 18-inch rifle which was made for these trials under a Congressional appropriation contains no essential patentable novelty. It weighs about fifty-nine tons, as against fifty-two tons for the 12-inch sea-coast rifle, and is thus but little heavier than the regular service piece, while it is capable of throwing a projectile of double the weight. A projectile weighing a ton can be thrown from it at a velocity of more than 2000 feet per second, as against a velocity of about 2300 feet per second for the 12-inch United States army rifle, with a projectile weighing 1000 pounds. The 18-inch gun has a muzzle energy of more than 51,000 foot-tons, as against a muzzle energy of 36,600 foot-tons for the 12-inch rifle.

Two targets were erected for the trials, one for the 12-inch projectile and the other for the Gathmann shell. Both targets were faced with a 11½-inch Kruppised plate, 7½ feet wide and 12 feet long, and backed by the regular coffer-dam construction in use on the United States battleship *Iowa*. The Gathmann projectile was made with a thin point, or nose, the shell being heavy toward the base and running down thin toward the point. The bursting charge was about 475 pounds of wet guncotton. Gathmann's idea was to detonate the guncotton on the face of the plate and destroy it by the sheer force of the blast of explosion, without any penetration whatever. It was this principle of outside explosion of guncotton on heavy armour plate which is said to have failed. Mr. Gathmann and his associates are understood to have expected that one Gathmann shell would blow the Krupp plate to fragments, and utterly demolish the entire target. It was not expected by them that a second shot would be necessary, and it was, therefore, proposed by them that the competition should be one effective Gathmann shot against the one plate and ten shots from the 12-inch gun against the other plate.

The first Gathmann shell was fired point-blank at the centre of the target, but it made only a slight dent in the face of the plate, and forced the target back very slightly. The shell did not completely detonate, and considerable pulverulent guncotton was found strewn about the target. The next Gathmann shell detonated fairly well, but the damage to the plate was but slightly more than from the first shot. The third, and last, Gathmann shell broke the plate in the middle, and the aggregate battering of the three shots forced the target back several feet. In the opinion of the trial board, an equal result would have been achieved had the Gathmann shells been charged with sand instead of guncotton, as the striking energy of these projectiles from the huge 18-inch gun represents a force equal to that required to lift a battleship of, say, 10,000 tons, to a height of about five feet.

In the case of the 12-inch gun the first projectile fired was an armour-piercing shot. It was charged with twenty pounds of dunnite, and was directed at the centre of the plate, through which it passed, exploding when about three-quarters of the way through, nearly the entire effect of the explosion being developed back of the plate, working tremendous destruction to the coffer-dam backing and timbered supports. The second 12-inch projectile was charged with twenty-five pounds of maximite, the invention of Hudson Maxim. This shot was fired at a reduced velocity, to represent a range of about four miles. The projectile penetrated the plate about half-way, when it exploded, splitting the plate longitudinally for about 11 feet, nearly its entire length, and breaking the right-

hand portion of the target, to which it was directed, literally to fragments, while the force of the explosion tore a hole through the plate much larger than the projectile, hurling huge fragments of both shell and plate through the coffer-dam backing, utterly demolishing it, some of the fragments flying far beyond. A portion of the base of this projectile was hurled to the rear a distance of about 1500 feet, where it was picked up. By far the greatest amount of destruction to the plate was done with this single maximite shot, while the greatest amount of destruction to the coffer-dam backing was, of course, wrought by the first projectile fired, which fairly exploded back of the plate. The armour-piercing shell, carrying sixty pounds of dunnite, was next fired at one of the largest pieces of the plate on the left, and this penetrated slightly before detonating, punching a large hole through it and hurling a big fragment, weighing a ton or more, to a distance of about 200 feet. It had been the intention to fire alternate shots of dunnite and maximite, but after the above three shots there was nothing left to fire at.

MAXIMITE and dunnite, or explosive "D," as the latter is otherwise known, the two high explosives adopted by the United States Government, have both proved to be wonderfully effective. Maximite appears to be somewhat more powerful, but both explosives are capable of withstanding the shock of penetration of the thickest armour plate, and they will not explode until set off by the detonating fuse. The detonating fuse used in the 12-inch projectiles is the invention of Captain B. W. Dunn, of Frankford Arsenal, and it does him great credit.

THE final report on the above-mentioned trials, made by the board of officers which conducted them, and transmitted to Congress a few weeks ago, presents the conclusion that "there is nothing in the Gathmann system to recommend its adoption in the service of the United States or to warrant further experiments." Others who are more particularly interested in the matter, however, and who have followed the progress of the Sandy Hook trials carefully, may form conclusions not quite in accord with the one given above. It is to be borne in mind that the trials, however conscientiously carried out, cannot, at their best, be regarded as more than what might be called laboratory experiments, conducted on a large scale, it is true, but nevertheless under conditions which have probably not been realised in any of the few modern naval battles that have taken place, and which are not at all likely to be realised in any future conflicts between armourclads, or between armourclads and shore batteries. Such conflicts have not been and will not be carried on at point-blank range, as was the case in the trials here considered, and in actual battle, or under probable conditions of actual battle, there is no case on record in which gun fire has penetrated modern face-hardened 12-inch armour. The fact, further, that in the Sandy Hook trials at least one of the 12-inch projectiles was fired at a reduced velocity, to represent a range of about four miles, and still went half-way through the plate does not prove that such penetration would have been effected with the target actually four miles off and the gun sufficiently elevated for that range. The gun, it must be remembered, was still fired point-blank. At actual four-mile range the angle of gun elevation and the angle at which the projectile would have struck the plate would probably have made a very considerable difference in the result,—a very slight degree of penetration, possibly, or none at all, and the explosion of a relatively very small quantity of explosive at the face of the plate with no perceptible effect. The armour-piercing projectile, in effect, would have represented nothing more than an aerial torpedo with an insignificant bursting charge. While these facts, if they be facts, would make little change in the

effectiveness of the Gathmann principle, they would most materially change the aspect of the armour-piercing or semi-armour-piercing projectile fire as recorded in the preceding paragraphs. They would wipe out practically all of the brilliancy of its effect, and leave its results meagre in comparison with what the Gathmann shell accomplished, however little that may be claimed to have been. Taken as they now are given, the Sandy Hook trial results do not carry with them a desired degree of conviction in either direction.

THE article on wireless telegraphy printed in this issue, with the illustration of an ancient Gaul shouting a message from a hilltop to a brother-in-arms some distance away, who, similarly, transmitted the message to yet another farther removed station, and so on and on, across a wide stretch of country in a short space of time, recalls the fact that this form of communication,—a species of wireless telegraphy we may be pleased to term it,—is in use to day by the peasantry in one of the Southern mountain sections of the United States to warn the proprietors of illicit stills when the revenue officers are on the warpath. When they come in sight of a cabin the tenant emerges with a tin horn and sounds a blast which is taken up at the next cabin, and so on along the trail to the heart of the mountains. There is nothing to seize when the raiders arrive at the suspected place, and when they retire, business is resumed.

IN the course of an address on standardisation recently made before the Institution of Civil Engineers, Mr. Charles Hawksley said that most British civil engineers had probably suffered inconvenience, and their clients loss, owing to the absence in Great Britain of standard sections of iron and steel. In the United States, where the American Society of Civil Engineers had issued standard sections for rails and standard specifications, the rolling-mill makers would in most cases roll only to those sections. From time to time inquiries had been sent from Great Britain to America for tenders for large quantities of rails and other materials, but in nearly every case the reply was that "unless you take our standards, we do not see our way to quote." On the other hand, some instructive instances of the waste of time and money in Great Britain for want of standard sections are available. One instance must suffice,—that of a section incorporated in a bridge for one of the British colonies. Here the average cost of the material was £8, 10s. a ton, but one of the sections specified was of such an odd size, and the quantity of it was so small, that it had to be made by a blacksmith at a cost of from £28 to £30 a ton. A striking case of the money wasted by unnecessary multiplication of the number of sections occurred recently, where the contractor endeavoured to obtain the sections specified for a certain bridge, but found that although they were contained in the price list issued by the makers, none were in stock, and delivery could not be made. The contractor, therefore, worked out a girder of equivalent strength, incorporating in it sections that could be readily obtained, and the saving on this one item was over £600. Germany has now sixty-seven various standardised sections and America only forty-nine, while Britain has no standard section and uses over 170 different ones.

THERE are few things more neglected, and yet more important, in the whole range of what may be called domestic engineering than the means of supplying air for warming and ventilating dwelling houses through the conventional type of hot air furnace so widely used in the United States. Unfortunately the exact way in which such a furnace operates is only dimly outlined in the mind of the average man or woman, and it has often seemed that a simple course in house furnace engi-

neering, issued in the shape of a couple of printed pamphlet pages, by some furnace maker for the benefit of his patrons, would prove a paying investment. It would help to dispel some of those crude notions that what issues from a hot air register opening in the floor or wall is, in the proper order of things, a mixture of air and furnace gas, and that ashes and dust quite as naturally must be expected to come with it. As to what might be called the refinements of furnace operation, such as the exclusion of dust from the outer air supply, which eventually goes into the house, the rational location of cold air intakes, the details of cold air duct construction, and some others,—they are rarely, if ever, given a moment's thought by the architect, or builder, or owner, or even the fairly pretentious dwelling. Some wholesome reading on this subject, given some time ago in *The Engineering Review*, is, therefore, worth commending. The entire article, which appears to have been written by an inspector of heating apparatus, would well bear reprinting, but only a few extracts can be given here.

"It should need no argument," says the writer in question, "to show that the air supply for a furnace should be clean, dry, as free as possible from dust, and as little as possible contaminated by the causes which, in cities, tend to vitiate air taken at or near the ground level. I have inspected a good many hundred furnace-heated houses, and almost without exception I have found the intake misplaced and the air-box in such condition that air drawn through it was as little fit for breathing as if strained through the wisps of a street-cleaner's broom. Sometimes I have found the air-box a clubhouse for cats; generally, it has needed cleaning with a hoe and shovel. Not long ago I found a house with an air intake consisting of a sort of combination air chamber and area cesspool. It was covered with a grating of parallel iron bars, through which the storm water which fell into the area drained to the pocket below, and was led away to the sewer by an untrapped pipe communicating with the house drain. This was, perhaps, the worst I have found, and my opinion is that the architect who planned this arrangement and the furnace man who worked to the plan should both be indicted. I had to hunt for the intake in this case for a good while before I found it. This is not surprising, since the arrangement was an impossible one and amounted practically to drawing air direct from the sewer, to be heated and passed up through the house.

"Sometimes one will find the air intake in the coal vault. I have notes of probably fifty such arrangements. This is ingenious, at least, and must make it pleasant for the housekeeper. In one house thus built, the amount of dirt distributed through the house suggested to the mistress the very natural expedient of stuffing the mouth of the intake full of jute potato bags, probably at a time when she expected a delivery of coal. They had been left there and forgotten for years, and when I pulled them out they were as rotten as punk. This did not interfere with the working of the furnace. True, no air,—or very little,—came in through the intake, but all that the furnace could heat was drawn from the cellar through the seams and cracks of the air-box, and nobody knew the difference. A very usual place for the air intake is in one of the vaults under gratings which are provided to light the cellar and ventilate it by affording places for windows. This expedient is the usual one when the air supply is drawn from the rear. Generally, these vaults are under the kitchen windows, and many things are dropped into them, by accident or intention, including more or less of yard sweepings. I have taken a good many pounds of food scraps, rotting cloths, dead mice, and miscellaneous rubbish from the bottoms of such vaults.

"THE conduit for conveying the cold air from the intake to the furnace is usually a wooden box, built of unseasoned spruce or hemlock. If of pine, the quality is so bad that it is useless for any other purpose. Before the end of the first season it more resembles a slatted chicken coop than an air conduit. In more than one instance the area of the cracks and openings admitting cellar air was equal to the cross-section of the box, so that the intake might have been tightly closed without interfering with the operation of the furnace at all. Such boxes usually have slide cut-offs provided, to reduce the volume of air admitted to the furnace when desired. As a rule, they are closed at some time for some purpose, and left closed thereafter. When this is the case all the air the furnace gets comes from the cellar. This is a very simple and economical method of cellar ventilation, but from the sanitary point of view it can not be commended as the best which could be devised. As a rule, air-boxes are extremely dirty. It rarely occurs even to careful housekeepers to have them cleaned. They will ordinarily be found crusted with dirt, —like bottles of old port in the cellars of ancestral castles,—only in the case of the air-boxes the dirt is on the inside, whereas in the case of the port bottle it is on the outside. Most people would be shocked if they should see what sort of a channel conveys the air which flows hot from the registers,—still more so if they could be made to realise that most of this air is from the cellar from which, once a year or so, in well-kept houses, barrels of dirt are removed, consisting of coal dust, ashes, sprouting potatoes, house rubbish of one kind or another, and mouldy nondescript refuse, the origin of which can not be guessed. In the average dwelling heated with a furnace, millions of cubic feet of cellar air are pumped up into living and sleeping rooms every winter. What it carries I leave it to the bacteriologists and the microscopists to say." In conclusion, attention is called to the fact that the typical wooden air-box, with its open seams, is an abomination, and should never be used. Instead, it should be made of zinc or galvanised iron, with tightly soldered seams, impervious to cellar air. It should in every case be provided with clean-out openings so that at least once a year the accumulated dust and dirt may be removed without pulling the whole structure to pieces. It should never be so arranged that its cut-off can entirely close it. Servants have very little intelligence in the operation of this kind of apparatus, and if the slide is pushed in, it is very likely to stay there until the head of the family goes into the cellar on a tour of exploration and discovers that it has been that way for weeks, and possibly for months.

IT appears to have been settled at last that the use of fireproof wood, at any rate in the United States Navy, will be very much restricted. In the recently issued annual report of Rear-Admiral Francis T. Bowles, chief of the Bureau of Construction and Repair, it is stated that the bureau, after having conducted an exhaustive investigation of the qualities of fireproofed wood produced by two different processes, has found that while the products of both possess desirable qualities in rendering wood uninflammable, they fail to show all the desiderata of a fireproof wood, which include the permanent retention of the ingredients under all climatic conditions, freedom from corrosive properties, and unaltered strength and durability. The experience of vessels in commission fitted with fireproofed wood, as well as the tests conducted by the bureau, showed that there was no practical advantage gained by the use of fireproofed deck planking, or by the use of fireproofed wood below protective decks, and also that owing to the absorptive qualities of this wood its use was objectionable in those locations. Hence the United States Navy Department has dispensed with the use of fireproofed wood in the Navy, except for such necessary joiner work as may be used above protective decks and on torpedo-boats.

SCHUYLER SKAATS WHEELER

A BIOGRAPHICAL SKETCH

By Gano S. Dunn

SCHUYLER SKAATS WHEELER is one of the types of men that contribute to our country's greatness. Although but little over forty, he is already a captain of industry, of noteworthy career, and his course is interesting to those who recognise in the organising of workmen and the handling of materials opportunity for character expression formerly considered limited to the old and classic professions.

A native of New York City, where he was born of Dutch descent in 1860, Dr. Wheeler was educated at Columbia College. Leaving there in 1881, he was employed as assistant electrician in the American branch of the Jablochkoff Electric Light Company, in the work of which historic corporation he took a great interest. The failure of the Jablochkoff "candle," the critical feature of their system of illumination by alternating currents, caused the dissolution of this company and the transfer of Dr. Wheeler's connection to the United States Electric Light Company, at that time coming into the field with the direct-current arc lamp.

His interest in central stations, which were then the great mystery as well as the great hope of electrical engineering, led him soon to seek a place on the staff of Edison, under whom he did his most important early work. He was present at the epoch-making opening of the Pearl Street station, in New York, and later, from the competence he displayed in its operation, was appointed in charge.

When the success of the Edison systems had proved the feasibility of central stations and of underground distributing conductors, other cities called for such equipment, and on account of his intimate knowledge of the art Dr. Wheeler superintended many of these installations. After laying the underground system at Newburgh, N. Y., he remained there for some time as superintendent of the Edison Company.

In 1886 central station engineering had solved some of its most important problems, and the operating of a plant no longer gave opportunity for development to men of the highest abilities. Dr. Wheeler, therefore, went into other fields. He was for a time electrician of the Herzog Teleseme Company, to which he contributed important inventions, and finally, in the establishment of his connection with the C. & C. Electric Motor Company, he entered the field of manufacturing, in which he has remained and in which he has made his greatest successes.

The C. & C. Company had just been organised by two friends of Dr. Wheeler, Charles G. Curtis and Francis B. Crocker, for the manufacture of small electric motors on the same scientific principles of construction that were embodied in the dynamos of that day, which were much further developed. It was the first concern of its kind in this country, and at the time of its organisation electric motors were more scarce in the metropolis than automobiles were five years ago.

To the accurate mechanical perceptions and creative ability of Dr. Wheeler, who was electrician and factory manager, were due many of the features which brought the company's motors immediately to the front and fostered general electrical manufacture. The new factory of the company in New York, the first shop in the country to

be devoted wholly to the manufacture of electric motors, was established under Dr. Wheeler's direction, and the company's early operations were very prosperous. Differences in the management arose, however, which caused a change in the whole policy of the enterprise, and in 1887 and 1888 Curtis, Crocker and Wheeler severed their connection with it, Crocker and Wheeler deciding to go into business under their own names as a firm and build electric motors of even a higher grade than they had been building in the C. & C. Company, for which kind of motors there was a rapidly increasing demand.

It was at this time that Dr. Wheeler was appointed expert of the Board of Electrical Control of New York, the onerous and exciting duties of which he performed while developing the new firm. The history of the time is full of the struggles of the great corporations, on the one hand, trying to maintain their labyrinth of overhead wires, so dense as to disfigure and make dangerous the city's streets, and on the other hand, the city ruling that the overhead structures must forthwith come down, and finally, under Dr. Wheeler's direction, actually felling the poles, amid the cheers of thousands of onlookers and the threats and actual violence of the owners of the destroyed property. This warfare brought upon Dr. Wheeler the ill-will of all the companies in conflict with the municipal authorities, but before the work of the Board of Electrical Control was over he had turned this ill-will into confidence and respect by his fairness and real protection of the electrical interests of the city.

With all that he contributed toward the putting underground of New York's wires and cables, Dr. Wheeler worked hard with his partner, now Professor Crocker, of Columbia University, pushing their manufacturing business, and they were rewarded with great success. After a time the firm of Crocker & Wheeler became the Crocker-Wheeler Electric Motor Company, after the formation of which and because Professor Crocker had been appointed to the chair of Electrical Engineering at Columbia, Dr. Wheeler resigned from the Board of Electrical Control and gave all his time to the new enterprise, of which he became president and general manager.

The organisation finally became the Crocker-Wheeler Company, of New Jersey, one of the most important builders of electrical machinery of to-day. When, in less than two years, its New York factory quarters were outgrown, it sought location out of town, having in view ultimate expansion to the limits of a great industrial corporation. At the new site in East Orange, N. J., the Lackawanna Railroad, through Dr. Wheeler's influence, opened a station, and in honour of the great French discoverer and investigator in electricity named it "Ampère."

In 1895, after three years of growth, the works were completely destroyed by fire; but while apparently a disaster, this was really a benefit, since the remodeled buildings that almost immediately arose were of the most modern kind, adapted to the manufacture of heavy machinery on a large scale, and fitted with perfect equipment in every respect. The promptness and energy shown in rebuilding were so remarkable as to cause universal comment, and by operating day and night in large tents and temporary sheds with electrically-driven tools the company succeeded in filling most of its orders and holding its business. Too much credit can hardly be given to Dr. Wheeler for the labours of the early days. Growth was so rapid that his company's capital was doubled, and doubled, and doubled again in the course of a few years, and with all this the great financial panic of 1893 and the fire just referred to were successfully met and passed.

While Dr. Wheeler possesses the true engineering mind, that broad judgment which seems to rise above calculations and intuitively determine the salient principles of an engineering problem, and while it is to this characteristic, producing valuable inventions and designs, that his early successes were due, it is not in this direction that he has done his latest and best work.

It is as an organiser and an executive, as an inventor of new methods of factory operation, to win success out of latter-day competition, that he has been pre-eminently successful, and has blazed a way into a comparatively new country of manufacturing economics. Industrial organisation in this country is carrying the lamp of progress far ahead into the darkness of old-fashioned and inadequate methods, and to such progress Dr. Wheeler is one of the men who have made great contributions. Poor Richard says:—"Take care of little expenses; the big ones will take care of themselves." This is also true of the thousands of little elements entering into the finished product of electrical and other manufactures. It is the insignificant things that maintain high costs, delay deliveries, introduce uncertainties into financial accounting, and, in general, cause manufacture to get out of joint. They are the skeletons in the closet of the industrial manager.

As an army without captains, sergeants, corporals, ranks, and files is a mob, so a factory without organisation carefully provided for the most minute elements of its product, is an uncertain quantity in the industrial warfare of to-day, and, sooner or later, must succumb. The art of war is old and its organisations are understood, but the art of manufacturing was born scarcely two centuries ago and developed only in the latter half of the century just past. It is not hard, therefore, to find in the still but imperfectly organised industrial fields room for such generalship as would occupy a Cæsar or keep a Frederick on his mettle, and it is in these fields that Dr. Wheeler has been busy.

To give in detail the methods he has employed and the results he has accomplished is beyond the scope of this sketch, but an example of them in one direction may be of interest. The tens of thousands of items of stock and finished parts involved in electrical manufacture it is beyond the powers of one man or even a group of men, by the ordinary methods of the past, to keep properly proportioned to the product that is finally formed; hence in large factories the merchandise or stock departments have been, on the one hand, a principal cause of failure of delivery owing to unforeseen shortage of material, or, on the other hand, they have been the depositories for extravagant excesses of all kinds of supplies, locking up large amounts of capital sorely needed in other parts of the business. The latter condition is usually the result of reaction from the great vexation and loss of time of hundreds of workmen, often caused by the lack of some insignificant item.

Owing, again, to the absence of correlation between the stock and the finished product, the merchandise or stock departments have become clogged with useless materials, these materials accumulating rapidly through undiscovered errors in ordering, the abandonment of types of product rendering their stock of parts on hand obsolete, and the over-ordering of special supplies prompted by the good old adage of being sure you have enough. This general confusion has been principally because the exact accounting for all the minute items of stock and the close relation of all materials to the orders the factory has engaged to fill has been considered too vast a labour to undertake, and an evil which it would cost more to cure than to endure.

Incident to the old systems have been the additional great losses incurred by an annual or semi-annual shutdown to take inventory, of which the cost is enormous if, besides the expenses of the actual counting, there is included a proper share of the unceasing fixed charges and the loss of profit resulting from loss of output, the profit being affected by the output in a geometrical ratio.

Dr. Wheeler, after much observation and study, and guided by expert accountants, deliberately undertook to incur the expense of a ledger account for every item of material and every finished part in his company's manufacturing and to provide such interdependent systems of specification-writing by the draughting department, order-issuing by the production department,

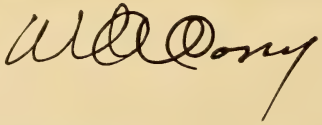
requisition-issuing by the purchasing department, and reporting of receipts and deliveries by the receiving and stock departments, that, once a factory order is booked and its details are completely specified, its course through the shop is almost automatic. Its execution, involving the labour of hundreds of workmen and the drawing or purchasing of perhaps thousands of items of stock, is no longer subject to the discretion of anybody, and, therefore, to his possible error, or neglect, but, through the functions of comparatively unskilled clerks, acting under careful system, it takes measures that it shall be provided with whatever it shall need at the time when it shall need it, and gives an indication that starts an investigation should its claims upon future supplies fail to be acknowledged and met.

The result of such provisions for dealing with the minute as well as with the greater elements of manufacture has proved to be a greatly increased output, a diminished cost of production, a minimum of capital locked up in inactive stock, shutdowns for inventories no longer a necessity, and a promptness and certainty of delivery that attract business. The mob, organised into files, ranks, corporals, sergeants, captains, becomes an army, mobile and efficient. Many others have contributed to the higher industrial organisation here referred to, but Dr. Wheeler has led in carrying it to some of its most successful developments.

Dr. Wheeler is a man of great force of character, expressing itself in a determined persistence in the accomplishment of his ends, well illustrated in his vigorous and successful handling of the recent machinists' strike, of which Ampère was one of the Eastern storm centres. He is devoted to his work, to which he applies himself most closely, and his liberality is shown by his recent purchase and presentation to the American Institute of Electrical Engineers of the Latimer Clark library, the most complete and rare collection in the world of early electrical books.

As an author, he has contributed to a number of subjects in the magazines and in the technical journals, and his book on the "Practical Management of Dynamos and Motors," written conjointly with Prof. Crocker, has gone through a number of editions and attained a large circulation. As a recognition of his work, Hobart College conferred upon him in 1888 the honorary degree of Doctor of Science. He is a member, and has been vice-president, of the American Institute of Electrical Engineers, and is also a member of the American Society of Civil Engineers, the American Society of Mechanical Engineers, the University and Lotos clubs, of New York; the Chamber of Commerce, of New York, and many other societies.

PHOTO BY PATTON, PITTSBURGH



PRESIDENT OF THE CARNEGIE STEEL COMPANY, LTD., PITTSBURGH

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CASSIER'S MAGAZINE

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THE NILGIRI MOUNTAIN RAILWAY

THE FIRST ABT RACK RAILWAY IN INDIA

By Walter James Weightman, M. Inst. C. E.

Apart from the features of engineering interest which it possesses, the Nilgiri Railway is notable as being the first Abt rack railway constructed in India, and one of the longest in the world. It is, moreover, the first for which all the plant and material was made in Great Britain, and one of the few that use wooden instead of steel sleepers.

Mr. Weightman's account of it, as given in the following pages, slightly condensed, appeared originally as a paper contributed to the Institution of Civil Engineers, and has been here reprinted by the special permission of that body. For the photographic views accompanying it, however, acknowledgment is due to Mr. Horace Bell, consulting engineer for the railway, who kindly loaned them for this reproduction.—THE EDITOR.

THE line starts from Mettapollium, a terminal station of the Madras Railway in Southern India, and ascends nearly 5000 feet to the plateau on the Nilgiri Hills, on which are situated the important towns of Ootacamund, the summer headquarters of the Madras Government, Coonoor, and Kotageri, two European settlements occupied chiefly by planters and retired officials, and near to which a government cordite factory has been established, and Wellington, the military sanatorium for British troops in South India and Burma.

The planters and other European settlers have for many years past agitated for railway communication with the plains, and as far back as 1874 Mr. Riggenbach visited the locality and submitted proposals for a rack line on his well-known system. The cost of this scheme (£400,000), however, was prohibitive. Several subsequent attempts at promotion were made, the most important of which was that of the late Mr. R. Woolley, a planter and contractor, who formed a company and constructed a considerable portion of the line. Financial difficulties, however, led to liquidation, and it was only recently that a new company, having received certain concessions from the government, was able to raise the amount required and to complete the line.

The principal ghat by which the Nilgiri plateau is reached, which is that followed by both the old and new roads, is a short, steep valley about six miles long, fairly straight, and with a slope varying between 1 in 8 and 1 in 4, with very few side valleys branching from it, in which to make distance. An adhesion line would have been almost impossible, as not only would it have been very lengthy and costly, but, owing to the absence of side valleys, it would have been difficult to locate without resorting to reversing stations, which the then

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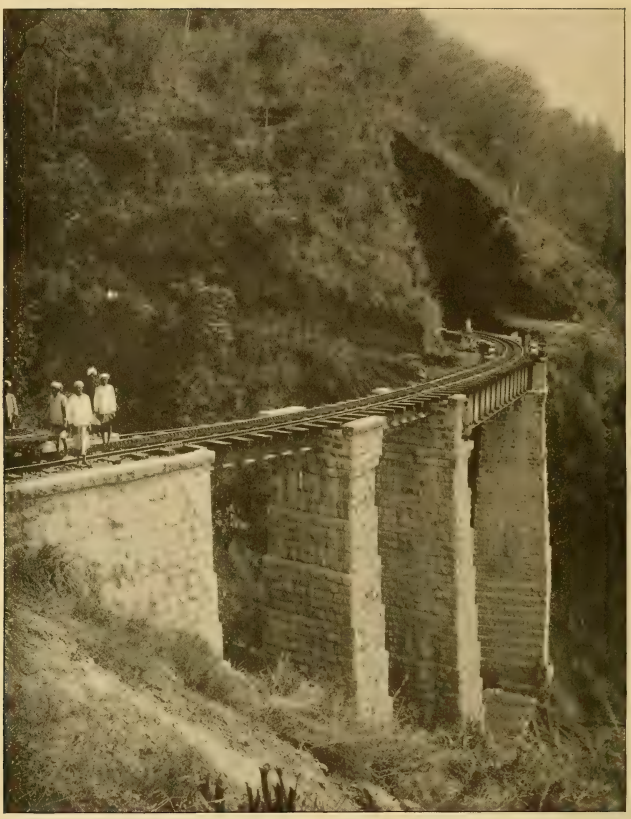


ONE OF THE VIADUCTS AND TUNNELS

consulting engineer did not favour. Everything, in fact, seemed to point to the adoption of a short, steep line with a gradient approximating to the slope of the valley; the other points requiring to be determined were the gauge, gradient, and system. The two former were settled by government, under the terms of the concession, for reasons given hereafter; and, with regard to the last, after a careful consideration of the relative merits of the Fell central rail and the Abt rack systems, the latter was decided upon.

The line is sixteen and three-quarter miles long. The first four and three-quarter miles have gradients not exceeding 1 in 40, and this portion is worked as an ordinary adhesion line; the remaining twelve miles are built on the Abt rack system, and have a ruling gradient of 1 in 12½, rising to a height of 5613 feet above mean sea level. The gauge is one metre (3 feet 3⅜ inches), and the minimum radius of the curves is 100 metres (328 feet). Of the whole line, nine miles consists of curves, five and one-half miles being of the maximum

curvature. There are four intermediate stations,—Kullar, Adderley, Hillgrove, and Runnymede,— which serve the adjoining coffee and tea estates, and are used as crossing and watering stations.

The survey for the line was a very arduous undertaking, owing to the dense jungle and steep hillsides which had to be traversed. The valley giving access to the plateau is merely a V-shaped mountain gorge with very precipitous sides, the lower slopes consisting of a talus of slips, centuries old, plentifully strewn with boulders lying in positions of varying degrees of stability. Such features did not afford much scope for choice in the location of the line, and the ruling gradient having been decided on, the general route of the line was not difficult to determine; all that was necessary was to start from the top of the valley and run a falling grade-trace down at the ruling gradient until it reached the bottom, utilising any side valleys passed en route to gain distance in places where the slope of the valley exceeded the gradient of the line.

The government decided that, with a view to possible connections with existing lines, the railway must be of the metre-gauge, and that the maximum gradient admissible was 1 in 12½. As it is desirable with the Abt system that the radius of curvature should not be less than one hundred times the gauge, this fixed the minimum radius of curves as 100 metres (328 feet).

With these data, it was possible to lay out roughly the general course of the railway. The sides of the valley showed a succession of alternate ridges and ravines, so that it was obvious that the most economical line would be obtained by using the sharpest curve freely, keeping the line as far out as possible when rounding ridges and as far in as possible when crossing the intervening valleys. The line thus consisted of a series of reverse curves with the minimum admis-

A 60-FOOT GIRDER SPAN

ADDERLEY, ONE OF THE FOUR INTERMEDIATE STATIONS

sible length of straight line (50 feet) between them.

The railway was located principally on a mean line, with the cuts somewhat in excess of the fills, the objects aimed at being, in addition to economy, (1) to keep the line as far as possible on the solid; (2) to avoid the too frequent use of retaining walls; (3) to avoid increasing the already heavy bridging; and (4) to reduce the banks to a minimum; for, with a rack line, it is important to use every precaution to guard against any possibility of subsidence of the roadbed.

But for the government ruling, a very great saving could have been effected by using a narrower gauge. Numerous rack lines have been built on the Continent with a gauge of 0.80 metre (2 feet 7½ inches) and curves having a radius of 60 metres (197 feet), and such a line would undoubtedly have "fitted" the country better and have greatly decreased the work.

The gradient is not compensated on the curves, the lengths of straight between curves being so short (frequently not more than 50 feet) that, allowing for the vertical curves at changes of gradient, it would have been almost impossible to do this. Seventy-five per cent. of the whole line consists of curves, and to have compensated would have added more than a mile to the length. Further, on a line with such a heavy gradient, the resistance due to the curves is so small as compared with the resistance due to gravity, that it is hardly worth considering. The line has, therefore, an uncompensated gradient of 1 in 12½, or, in effect, a compensated gradient of 1 in 11½.

In several places the ground was so difficult and inaccessible that a very careful and elaborate triangulation, plotted to a large scale, was necessary in order to locate the line. The most troublesome places were the Benhope Cliffs, where the line passes for 1000 feet along the face of an almost vertical cliff 2000 feet high, and the Burliar valley, where it crosses a gorge by a bridge 150 feet long and 120 feet high, and then immediately enters a tunnel, 275 feet long, in the face of the cliff. In both places the survey was very difficult, and ropes secured to jumpers let into the rock had to be used to get any foothold at all.

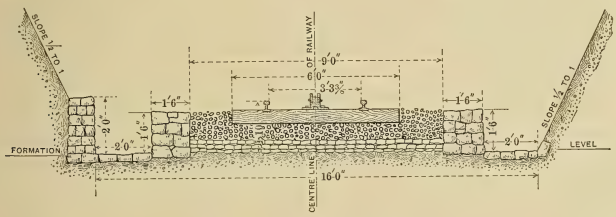
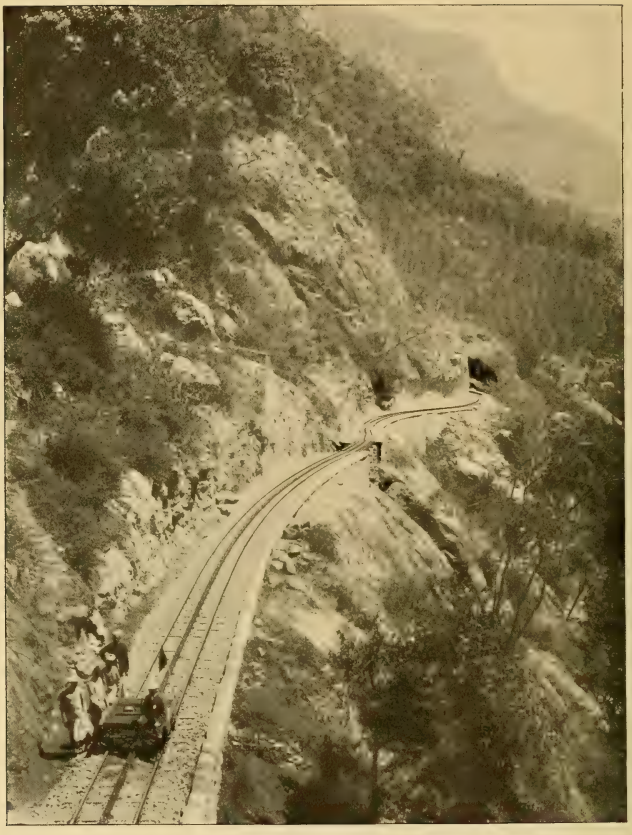


FIG. 1.—CROSS SECTION OF THE ROADBED

It was found to be of very great advantage to build masonry "balance-point" pillars, before the earthwork was commenced, at all points where bank and cutting met. These were built to true formation level, and correct centre line; they thus served as permanent bench-marks and theodolite stations during construction, and are available for use still. The service footpath was made from balance-point to balance-point, contouring round the spurs and up the ravines.

The earthwork was very heavy throughout, and amounted to about 40,000,000 cubic feet. It consisted chiefly of hard rock or of boulders embedded in earth and disintegrated gneiss. These boulders were of granite, and weighed in many cases several hundred tons. Dynamite was the explosive chiefly used, and the consumption amounted to about 180,000 pounds.



THE BENHOPE CLIFFS, ONE OF THE MOST DIFFICULT SECTIONS OF THE LINE

No hard-and-fast rule was made with regard to the slopes of cuttings, each being dealt with according to circumstances; but they were generally taken out with slopes as steep as possible, in order to minimise the disturbance of the hillside above, and to expose as little new surface as possible to the action of the weather. In heavy sidelong ground, if much flattening is done, the uphill slope becomes a serious matter, and the denudation of vegetation tends rather to encourage slips than otherwise. This policy naturally resulted in numerous slips in the first heavy rains, but it was thought better to let Nature point out the places where additional sloping was needed, rather than to go in for excessive sloping throughout the whole line at the outset. Catch-drains above the cuttings were quite out of the question, owing to boulders and rocks and general roughness of the ground.

The growth of vegetation on the slopes of both banks and cuttings was encouraged everywhere. Experiments

were made with different kinds of grass for turfing, of which Guinea grass was found to be the best, owing to the length and tenacity of its roots, which gave it great power of holding the soil together.

The formation was everywhere 16 feet wide (Fig. 1), and the greatest possible care was taken to see that it was effectually drained. In countries where a rainfall of 6 inches in as many hours is of frequent occurrence this is a most important consideration.

Ballast walls of dry stone, 18 inches high, were built throughout the mountain section. The side drains were of the minimum dimension of 18 inches by 18 inches, and were pitched with dry stone. On the top of the formation 6 inches of large stone soling was laid; then 6 inches of small 2-inch ballast, and afterwards 6 inches of boxing in ballast, put in after the platelaying was done. All ballast used was good sound broken granite. The outer side drains were turned off every 100 feet, except in a few long cuttings; the inner side drains were led into culverts or to earthenware pipes under the line.

There are nine tunnels on the line,—all short ones,—the longest being 325 feet. They were all driven by hand labour, and only one gave any trouble and required skilled labour for the timbering; seven of the nine were on curves of 328 feet radius, and one was driven from two side adits in the face of the cliff, as the tunnel face was inaccessible. In tunnels through hard rock a top heading was run, and in soft ground where timbering was needed, a bottom heading. The lining, where required, was of stone with lime or Portland-cement mortar. The cost of the unlined tunnels was £7 per lineal foot, and of the lined tunnels £12 per lineal foot.

The air in the tunnels gets very bad when the engine has a full load, especially if fuel has just been added, due to the continuous up-draught caused by the incline which makes the smoke and gases travel at the same pace as the train. The tunnels are so short, however, that this has caused but little inconvenience. A section of half tunnel, of the kind illustrated on page 289, was used in two or three places where the line passes along the face of a cliff.

The retaining walls were numerous,—about 120 in all,—and of various degrees of importance, the biggest wall being 63 feet high and 200 feet long. At first they were all built of dry stone with a batter of 1 in 4 on the face, but afterwards all important walls were built in lime mortar, and the batter was increased to 1 in 3, the high ones being buttressed also. Dry stone walls, however carefully built, are undoubtedly a source of weakness on a line subjected to excessive rainfall, and, in the author's opinion, should not be used for heights over 10 feet; in the case of revetments pure and simple the same objection does not hold.

The bridgework was heavy for the length of line, comprising twenty-three large bridges and one hundred and thirteen small ones. The longest bridge, over the Kullar River, was 450 feet long; the highest, at Burliar, was 120 feet high. Of the large bridges, only eight were over rivers properly so called, the remainder being over deep gorges, dry except after rain.

The design of the large bridges was uniform, though slightly modified to suit local circumstances. Several alternative designs were prepared, and it was found that the cheapest type to adopt was plate girders on masonry piers, the fall in the exchange value of the rupee precluding the use of the steel piers originally intended.

Excellent stone was obtainable along the whole route, but lime was not procurable, and had to be brought up from the plains by road from Karamadi. Scarcity of sand also was a difficulty, for mountain gorges are not favourable to its deposit. Such sand as could be had was brought up from the plains, and most of it was of inferior quality, although the result of a series of briquette tests showed that inferior sand, if the lime is good, does not affect the quality of the mortar as much as is generally supposed. The masonry consisted of coursed rubble, set in lime mortar. The abutments were quite plain, with square return walls; the piers, instead of being

battered, had insets every 4 feet, as being neater and easier to build.

The use of plate girders was decided on, because most of the girders had to be laid on a gradient of 1 in 12½, and 10½ inches, so that by placing the girders and bed-stones 1 foot up stream out of the centre, and thus dividing the versed sine, it was possible to reduce the distance between centres of girders

RUNNING A GIRDER OUT FROM A TUNNEL MOUTH

it was thought that, with any form of lattice girder, the rigid butting necessary at the lower end to prevent creep might possibly cause buckling; the girders are of steel, and were designed according to the Government-of-India rules, namely, double the moving load added to the fixed load, and a stress of nine tons per square inch.

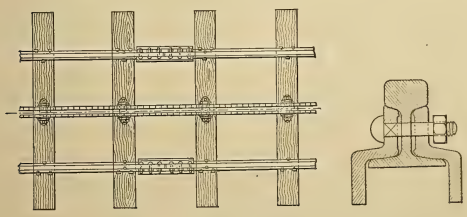
Sixty feet was fixed as the maximum desirable span, because, as most of these bridges were on a 328-foot curve, any longer span would have necessitated long cross girders to provide for the curvature of the line on the bridge. For the same reason in all cases the road was carried on the top flanges, on transverse sleepers, thus rendering cross girders unnecessary. The versed sine with a 60-foot girder on a 328-foot curve is 1 foot to 5 feet 6 inches, which was not too great for hardwood bridge sleepers.

All the pier foundations were on bed rock, which was carefully benched, and in some cases steel jumpers also were let in. The only one that gave any trouble was the centre pier of the Bawani Bridge, which was on two 10-foot masonry wells sunk by divers through the boulders in the bed of the river. Besides forty-five smaller spans, there are thirty-two spans of 60-foot girders, and these were put together and riveted complete with all cross bracing, bridge sleepers, etc., at the base, run up on two bogie trucks, and pushed across into place by an engine over a temporary bridge formed of sleeper stacks and rolled beams. This effected a very great saving of time as compared with the

usual practice of putting together and riveting *in situ*.

The 100-foot spans over the Bawani required different treatment. As this river is subject to floods at all seasons of the year, falsework was inadmissible. The spans were riveted up on the bank complete, with all cross girders and bracing, etc.; a low-level surface line with four lines of rails was laid between piers on cribs across the river, and on this ran a timber gantry carried on four bogies, and of the full height of the piers. The ends of a pair of 100-foot girders were placed on this gantry, which was then traversed across, carrying the girders with it; in this way a complete span weighing between fifty and sixty tons was launched in half an hour.

In one case only is the span of 60 feet exceeded on the ghat section, and that is at Burliar, where an 80-foot span with buckle-plate flooring was used. This gave some trouble in erection, as it spanned a rocky gorge 120 feet deep on a 328-foot curve, and with a curved tunnel at one end, through which the launching had to be done, thus precluding the use of derricks or other similar appliances. A low-level girder bridge, as shown in the illustration on the opposite page, with a span of 35 feet, was constructed across the bottom of the gorge, and on this was built a timber trestle nearly 60 feet high. This formed the basis of a temporary bridge, over which rails were laid and the girders were run across on bogies, having first been riveted up in the tunnel.



FIGS. 3 AND 4.—THE PERMANENT WAY

On the mountain section most of the girders were laid on a gradient of 1 in 12½, and it became necessary to devise some means of preventing them from moving downhill. On single-span bridges a heavy angle-bar, 6 inches by 6 inches, was riveted to the bottom booms of the girders at the lower ends and this angle-bar, as well as the endt of the girders themselves, butted agains the masonry of the lower abutment, the upper ends of the girders being left free for expansion. On bridges of more than one span, a pair of heavy cast-iron bed-plates (Fig. 2) was securely bolted to the top of each pier. The top surface of this bed-plate was parallel to the incline, and to it were bolted the girders, the upper end of the lower span having provision for expansion, and the lower end of the upper span being fixed to the bed-plate and provided with an angle-bar, to butt against it as for single spans. These precautions have been successful, and so far no movement of the girders has taken place.

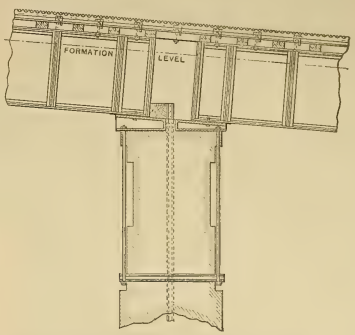


FIG. 2.—HOW THE BRIDGE GIRDERS WERE PREVENTED FROM SLIPPING DOWN HILL

The permanent way consists of 50-pound steel flat-footed rails, 28.14 feet long, laid on wooden sleepers, eleven to the rail, with deep, six-holed fish-plates, weighing forty pounds per pair, fitting in between the sleepers (Figs. 3 and 4). The sleepers are of Burmese "Pyngadu," a very hard, dark, compact wood, which,

when well seasoned, resists the attacks of white ants. They are spaced 2 feet 6¾ inches apart, the ordinary size being 6 feet by 8 inches by 4½ inches; but on the ghat section, where they have sleepers, and are of the ordinary Abt pattern (Fig. 7).

The whole of this material was manufactured by Messrs. Cammell & Co., of Sheffield, who devised a special machine

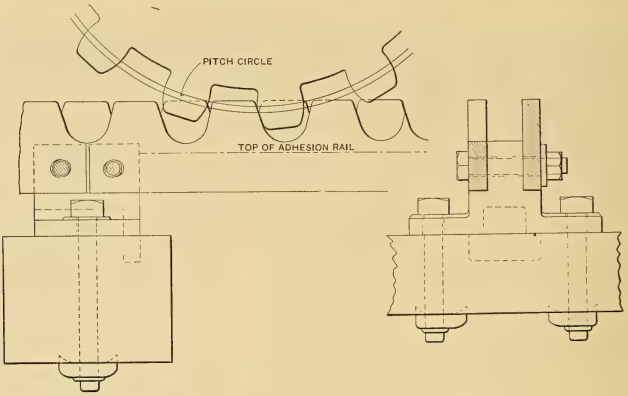


FIG. 5.—THE ABT RACK IN ELEVATION AND CROSS SECTION

to carry the rack also, the thickness has been increased to 6 inches, to guard against anything like warping, which, however slight, would alter the relative height of rack and rail.

On all gradients steeper than 1 in 40 a double Abt rack is used (Fig. 5). From Kullar to Coonoor (twelve miles) the rack is continuous, except for three short breaks where the stations occur. The rack bars are 3.116 metres long (covering four bays of sleepers) and 22 millimetres thick (Fig. 6). The two bars are laid so that they not only break pitch, but also joint. They are made of flat bars of steel, with a tensile strength of thirty tons per square inch, and the teeth are formed by machine-slotting from the solid. The greatest care was exercised in making them, as regards pitch, shape of teeth, length of bar, and position of bolt holes. Every bar was applied in the works to a metal stud template to test its accuracy before it was accepted. The rack is carried by cast-iron chairs which are fixed to the sleepers by two ⅞-inch fang-bolts; the spring entering tongues are on steel for slotting the teeth. This was the first instance of any rack-railway material being made in England. The price paid for the steel rack was £14, 10s., 9d. per ton f.o.b., plus a patent royalty of £5, 2s., 9d. per ton. This rate was considerably lower than the figures quoted by the German firms who had hitherto had the monopoly. The rate per mile for the double rack with chairs and all fastenings, but excluding rails, sleepers, and laying, was £1408, equivalent to 16s. per yard. The weight per yard was ninety pounds for all bars, chairs, and fastenings. The spring entering tongues cost £32, 15s., 2d. each, f.o.b. complete.

The whole of the permanent way had to be laid with the greatest exactitude; all the rails were bent truly to the curves by machine, and the laying of the rack itself was a somewhat troublesome process. The spacing of the sleepers is fixed absolutely by the rack, and owing to the use of deep fish-plates (Fig. 4), it became necessary to have the rail-joints not only square with each other, but also exactly midway between the two

adjacent sleepers. There was no difficulty in doing this on the straight, but on curves it was necessary to use rails of different lengths for the outside and inside. If the joint did not come exactly in the centre, it was possible to notch either the upper or the lower sleeper to receive the fish-plate, but no deviation of more than 1 inch was allowed. Rails of the required lengths for all the different curves were cut, drilled, and bent by machine in the depot, and were painted different colours and stacked separately, a table being given to the man in charge of the rail-bending machine, showing the versed sine required for different curves. The sleepers also were notched for the rail-cant, and the rack chairs were fixed on them in the depot before they were taken out; the rack bars required for curves were also bent and stacked separately.

The use of wooden sleepers was somewhat of a novelty. On all the Continental Abt lines steel sleepers are used, the only other line using wooden sleepers being the Pike's Peak Railway, in the United States. Wooden sleepers are cheaper, more easily renewed, less damaged by slips or derailments, give a more flexible road and offer more latitude in the spacing, as the chairs need not be fixed exactly in the centre of the sleeper, but can be moved slightly uphill or downhill as best suits the rail joints. The cost of platelaying, including rough packing, was 2s. per yard, and the progress rarely exceeded 500 feet per day; any attempt to increase this resulted in bad joints and careless laying.

The rack bars were made 2 millimetres short at each end to allow for expansion and contraction, so that at each joint chair there was a gap of 4 millimetres. On the straight this gave no trouble, as the space was the same throughout, and the joint-pitch was always correct; but it is obvious that on curves the inner rack must be slightly shorter than the outer, and that, the rack bars being all of the same length, this difference must be allowed for at the joints. Hence, on curves, all inner joint-pitches had to be made slightly tight, and all outer joint-pitches slightly slack. It was essential to divide the error, because if the inner joint-pitch were made correct the outer one would be so wide as to be dangerous, and vice versa. The difference in length on a 328-foot curve was 2 millimetres, so that it was necessary to make the joint gaps of the inner rack 3 millimetres wide and those of the outer rack 5 millimetres. This difference would be reduced by using shorter bars of two instead of four-sleeper bays.

For the adhesion rails ¼ inch was allowed for expansion at the joints. The observations of the author, however, tend to show that, on a line consisting principally of curves, expansion and contraction does not take place parallel to the line, but that the force is expended in slightly bulging or flattening the curves, owing to the resistance of the ballast at the sleeper ends being less than that of the fished joints. Inspection of the ballast on curves distinctly showed that there had been lateral movement of the sleepers. If this theory is correct, it would be possible, on a mountain railway where curves largely preponderate, to lay the rails with ends butting, thus giving increased smoothness of running and less wear and tear to rolling stock.

No precautions have been taken to prevent creep, as with the form of permanent way and rack used it is believed that its occurrence is impossible. The deep form of fish-plate (Fig. 4) prevents a rail from moving downwards without pushing before it the sleeper supporting its lower end; but this sleeper, being chained to all the other sleep-

FIG. 6.—ONE OF THE RACK BARS

ers by the rack, cannot move unless it drags them all with it, and the total resistance of the ballast is sufficient to prevent this. In fact, the rack bars and rails combined form a sort of rigid frame, the rails acting as struts and the racks as ties.

All changes of gradient are rounded off by vertical curves of large radius (usually 3759.4 feet), which prevent anything of the nature of a jerk to the train as it passes from one gradient to another. As the engine pushes the train it is always at the downhill end; consequently, when approaching a rising gradient, the train will be on the incline before the engine, and it is thus necessary at each station or break of rack to commence the rack a train length (150 feet) in advance of the commencement of the incline. On a falling gradient, that is, at the downhill ends of stations, this is not necessary, and the rack begins slightly below where the incline commences.

The superelevation on curves is greater than would be given by using the ordinary speed formulas; it ranges between 1½ inch on the curve of minimum radius (328 feet) and ¾ inch on that of 716 feet radius. On girder bridges this superelevation was given by raising the outer girder, thus avoiding excessive notching of the bridge sleepers.

On all curves the line was laid slack to gauge, the amount of slackness varying between ½ inch on 328-foot curves and ¼ inch on those of 716 feet radius. It was found preferable to give the whole of this slackness to the inside half of the gauge instead of half on each side. When passing round curves the tendency is for the leading wheels of the engine to hug the outer rail, so that if the rack is placed the correct half-gauge from the outer rail the gearing of the pinion is better than if the rack were placed truly in the centre of the widened gauge.

The author conducted a series of experiments to determine the exact position which the pinions take when passing round curves. The teeth of the two pairs of pinions were dabbed with red and black paint, respectively, and as they passed over and depressed springboards fixed to the sleepers, a record was left by the paint of the positions taken by the two pinions with respect to the rack. The results showed that the leading pinion was well over towards the outside of the curve and the trailing one towards the inside, which gives a slightly crablike motion to the engine, and means some loss of power in friction till the teeth become worn to this condition of things. The experiments also showed that if any widening of gauge was given to the outer half, the leading inner pinion approached perilously near to the outer rack, and as the rack teeth break pitch, this was a thing to be guarded against.

The rolling stock consists at present of four rack locomotives, sixteen goods waggons, four first-class coaches, four composite coaches, and four brake vans. The engines are what are known as "combined" Abt engines, that is, they can run on either a rack or an ordinary line. There are four cylinders, the outside pair, 11½ inches by 18 inches, for the adhesion wheels, and the inside pair, 10 inches by 14 inches, for the rack pinions. Each engine has six wheels, 2 feet 6 inches in diameter, the trailing pairs being coupled; the wheel-base is 10 feet, and the total weight in working order is thirty-three tons. This wheel-base was somewhat long for the sharp curves, but the wear of the tires has been very much decreased by the use of a jet of hot water. The engines carry 625 gallons of water in side tanks and one ton of fuel in a rear bunker. They were built by Messrs. Beyer, Peacock & Co., of Manchester, who have introduced in them some novel features.

In the ordinary Abt engine the frame carrying the rack pinions and gear is slung from two of the main axles by means of two additional bearings on each axle between the main frame plates. The object of this is to prevent the motion of the springs from influencing the height of the pinions above rail level, as it would if they were carried by the main frame. In the Peacock engine the rack frame is attached direct to the main axleboxes,

thus avoiding the use of the intermediate bearings. Another improvement is that the rack pinion is not driven direct, as is usual, but by spur-gearing, and that both the leading and trailing pinions are driven by the same spur-wheel, thus increasing the safety and making the pressure on the rack teeth half what it is with the ordinary Abt engine, in which all the power is transmitted by one pair of pinions only, the second pair being used merely to give additional brake power.

The load taken by these engines up inclines of 1 in 12½, at four and one-half miles per hour, is nominally sixty tons, excluding the weight of the engine; but although in certain specific trials this load has been taken, for ordinary running it has not been, so far, possible to ensure generally a greater load than forty-five tons to fifty tons. As the same trouble occurred with the Usui Toge engines, in Japan, and also with those of the Transandine and Snowdon lines, there must be some reason for this divergence in the case of rack engines between the theoretical load and the actual load taken.

In mountainous countries it is nearly certain that damp, moist weather will be the rule rather than the exception, and that the normal condition of the rails will be greasy; so that while a coefficient of adhesion of one-fifth, or even higher, might be possible on an ordinary railway, when designing an engine for use on a mountain line such as this, the coefficient adopted in the calculations should, in the opinion of the author, not be greater than one-seventh. In the case under consideration the makers' calculation showed that a coefficient of $\frac{1}{4\cdot8}$ would be necessary in order to obtain the full power of the adhesion cylinders, and the opinion was expressed that with the steam-sanding apparatus such a coefficient should be obtainable. The author differs on this point, and does not think it would be possible to rely on such a high coefficient, even if steam-sanding were practicable during the whole ascent, which it is not. Further, when determining the load which a rack engine should take, an unknown factor has to be dealt with, namely, the friction of the rack gearing. For an ordinary engine, an allowance of between ten pounds and twelve pounds per ton would be ample at low speeds to cover the rolling resistance of the engine, and the friction of the motion and gear; but in a rack engine there must be added to this not only the friction of the rack engine itself, but the friction between the pinions and the rack. It would not be correct to assume that the power is transmitted by the rack gearing without loss, for, as has already been explained, on curves the rack is not perfectly accurate.

To provide for slight inequalities in the rack, the engine pinions are in two parts, and are provided with six spring keys, which have the effect of giving a certain amount of elasticity to the teeth and ensure each pinion taking up its fair share of the work.

The engines work very smoothly on the rack, and the gearing, after the teeth have become slightly worn, is perfect. The cost of each engine was £2600, or at the rate of about £75 per ton, as against £45 to £50 per ton for ordinary engines of similar weight and gauge.

The trains are very powerfully braked. Each engine is provided with the Chatelier air-brake, on both rack and adhesion cylinders, and, in addition to an ordinary hand-brake, has the vacuum automatic brake acting on all six wheels. Each rack pinion also is provided with a powerful hand-brake actuated by another hand-lever from the cab. This brake consists of a steel band with brass linings, the brasses being serrated to fit the drums against which they press, and the drums being keyed on to the pinion shaft.

Before the line was opened for traffic a series of brake experiments was made with a fully loaded train of 100 tons gross weight, and the results were most satisfactory. With an ascending train at speeds of six miles, eight miles, and ten miles per hour, stops were made in 24 feet, 36 feet, and 60 feet, respectively; while with a descending train on a 1 in 12½ gradient at speeds of four miles, five miles, six miles, seven miles, eight

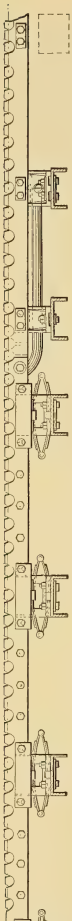


FIG. 7.—THE ENTERING TONGUES FOR THE RACK RAIL SECTION

miles, ten miles, and twelve miles per hour, stops were made in distances of 54 feet, 70 feet, 92 feet, 112 feet, 133 feet, 243 feet, and 425 feet, respectively.

The descent is usually made on the Chatelier brake only, this ordinarily being found sufficient to control the train. The vacuum and hand brakes are available for emergency stops.

No paper on rack railways would be complete without some remarks on the vexed question of the danger of the pinion mounting the rack. The author has had exceptional opportunities for studying this matter, and has caused wilful derailments in order to investigate it more thoroughly. The conclusion arrived at is that in almost every case the mounting of the rack is the result, and not the cause, of the derailment. If the road is not in good order the engine will become derailed just as an ordinary engine would; the result is that the pinion mounts and damages the rack, and this is erroneously assumed to be the cause of the accident. If everything is in good order there is no more reason why a rack engine should leave the road than an ordinary engine; on the contrary, there is less reason, for the rack bars, breaking pitch, as they do, act in some slight degree as check rails; but if a rack engine does get off the road the consequences are naturally more serious, for by the disengagement of the pinion the engine's most effective brake is rendered useless. To guard against dangers of this sort it is essential that a rack line be laid with the greatest care and accuracy and be kept in perfect order, special attention being given to packing with good sound ballast. Packing should always be done from the lower side of sleepers, and more than usual care should be taken that no packing is done in the centre of the sleepers, and that there is no subsidence of the roadbed. It is most important also to lay the line on the curves mathematically correct. One apparently inexplicable derailment was found to have been due to careless bending of a rail, by which all the curvature had been given at one place instead of being evenly distributed over the whole length.

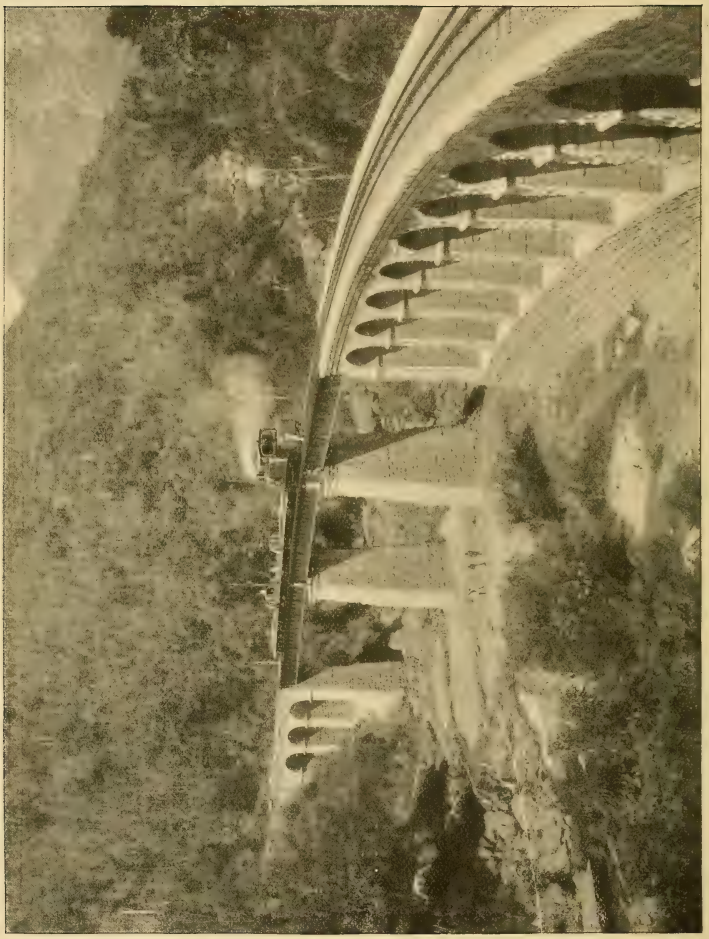
It is impossible for a pinion to mount the rack unless there be an error of not less than ½ inch in the rack-pitch. From the nature of the bars this could happen only at a joint, and there only if the line were actually broken or seriously damaged. The bars are not strong enough to bear the weight of an engine, —they bend before lifting it; even a stone on the rack is not sufficient to cause mounting; it is either forced between the bars or crushed between the teeth. The only way in which mounting is conceivable is by the pinions becoming locked, and this could occur only with a very powerful brake. In no case should a brake of such power be used as to render locking of the pinions possible. On the Nilgiri Railway the rack-brakes, both of the engine and of the vehicles, are worked by hand only, and it was found by experiment that it was impossible to exert sufficient force on the lever to prevent the pinion from rotating.

All the derailments occurred during construction, before the line was properly packed; since then there has not been the slightest trouble, except in the matter of slips in the cuttings. The gearing improved after the teeth had become slightly worn, and is now perfect; the "staggering" of the rack teeth prevents the jerky motion felt on some of the older rack lines, and the transition

from the adhesion to the rack sections is hardly noticeable either in the carriages or on the foot-plate. The working of the Abt system on this line may be pronounced a distinct success.

At each of the crossing stations there is a short length of level road, laid without the rack. This enables points and crossings (1 in 6) of ordinary pattern to be used instead of the rather complicated rack ones. The accommodation consists only of a crossing siding, a lay-by siding, water tank and ashpit. At the terminal stations ample sidings, engine sheds, ashpits, goods sheds, platforms, etc., are provided. As the engine tank holds only 625 gallons, it is necessary for all ascending trains to water at each station. The speed is limited to eight miles per hour on the ghat section, and twenty miles per hour on the adhesion portion, and for safety the engine is always at the downhill end of the train, and pushes instead of pulls.

A HALF-TUNNEL



THE KULLAR RIVER BRIDGE, THE LONGEST ONE ON THE LINE

The use of turntables at the termini is thus unnecessary.

The line is now being worked by the Madras Railway Company, who have prepared a very complete code of rules for working, embodying every possible precaution to ensure safety, and with special rules to guard against the breaking away of a waggon at any of the intermediate stations on the ghat. An excellent system of patrolling the line is also in force, and every portion is traversed by the watchmen at least three times a day, night running not being allowed for the present.

The grease used for lubricating the rack is a mixture of tallow, soft soap, castor-oil, and black lead, boiled together, it being necessary to use a lubricant which does not harden, does not readily melt in a hot sun, and is not palatable to ants or other insects. The rack is greased once a week by a greaser, but greasing automatically, as the engine pinions travel over the rack, is contemplated. At present four trains each way are run daily, two passenger and two goods trains.

In conclusion, a few remarks may be offered on the important question when and under what circumstances a rack line is to be preferred to an adhesion line. In the case of the railway here described, the circumstances were peculiarly adapted for making a steep railway, and an ordinary adhesion line was almost out of the question. If the same curves and gauge had been adopted, an adhesion line would have cost as much per mile (less a small amount for the cost of the rack itself), and even with a gradient reduced to 1 in 25 the length would have been doubled and the cost nearly so, and the scheme would have become financially impossible. At the same time, while allowing that a rack line was the most suitable in this case, the disadvantages of the system must not be lost sight of. As long as everything is in good order a rack railway works perfectly; but the whole thing is in reality a machine, and, like a machine, is easily put out of order. A small boulder falling on a rack bar is sufficient to bend it and to stop traffic until it has been replaced. If a rack railway is to be a success it must be very carefully and substantially built, and must be maintained in perfect order. Every mountain railway is a problem in itself, which must be solved independently. It is a mistake to suppose that, because a special system has proved a success in one place, it will necessarily be so in another where the circumstances may be quite dissimilar.

Rack railways have proved themselves to be most ingenious and efficient means of negotiating steep gradients, and to be satisfactory in every way when used in the right place. It is impossible to formulate any rules as to when to use them; but, unless the circumstances are very exceptional, they should be avoided on important or trunk lines. The interpolation of a length of rack on a main line would be almost as objectionable as a break of gauge, and in most cases the alternative adhesion line would be decidedly preferable.

Generally speaking, the most suitable place for a rack railway is for a short branch line to reach a hill station or other elevated spot, provided (*a*) that the traffic will not be very heavy; (*b*) that there is no probability of this branch being extended at some future time and becoming a portion of an important trunk line; (*c*) that the average slope of the valley or country to be traversed lies between 1 in 5 and 1 in 15, enabling a fairly direct line of, say, 1 in 10 to 1 in 12 to be made at a moderate cost; if the slope of the ground is flatter than this an adhesion line will probably better serve the purpose.

The cost of the line was approximately £15,000 per mile. An extension of eleven and one-half miles is contemplated, consisting of three and three-quarter miles of rack and seven and three-quarter miles of adhesion railway; the estimated cost of this is £11,000 per mile.

The line was constructed by the author, with Mr. E. S. Alexander, Assoc. M. Inst. C. E., and Mr. A. H. Butcher, Assoc. M. Inst. C. E., as district engineers, the consulting engineer being Mr. Horace Bell, M. Inst. C. E.

A MODERN FOUNDRY

A GOOD EXAMPLE OF DESIGN AND EQUIPMENT

By Albert L. Rohrer

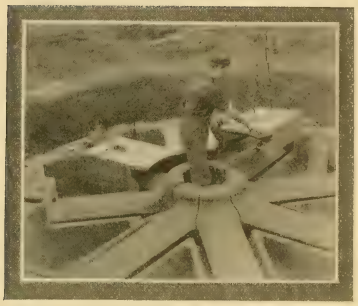


FIG. 1.—SETTING CORES

IN 1897 the works at Schenectady, New York, of the General Electric Company found itself with an iron foundry entirely too small for the company's rapidly increasing business, and the board of directors, therefore, wisely decided to erect a new foundry with sufficient capacity to take care not only of the present demands, but also to provide for future increase. It was left with the works management to solve the problem, and how this was accomplished it is the purpose of the writer here to show. The outcome, it may be remarked at once, was in all respects a model foundry installation, and as such the particulars and illustrations of it, as here presented, are of general interest.

After a careful study, plans and specifications were prepared and sent out on March 3, 1898. Contracts were let on March 25, and on April 12 the contractor broke ground for the building. The structure as originally put up measured 503 feet × 140 feet, with a cleaning room wing, 103 feet × 120 feet, and a lean-to, 40 feet × 243 feet, making a total floor area of 92,600 square feet. It was completed on December 31, 1898, and on January 5, 1899, the first metal was poured.

Within a few months, however, this large foundry was found to be too small, and plans were drawn for an addition of

FIG. 2.—THE BUILDING FOUNDATIONS. CONCRETE PIERS CONNECTED BY STONE WALLS

240 feet to the main building and lean-to, so that the building now measures 140 feet × 743 feet, with cleaning room and lean-to above mentioned, and has, therefore, a total floor area of over 131,000 square feet, or about three acres, not to mention the areas included in the numerous sheds for storing the various foundry supplies of sand, coke, facings, and others. The building is of modern construction, having a steel framework and curtain walls of brick. The steel columns, 40 feet apart, rest on large piers of concrete, which are connected by stone walls.

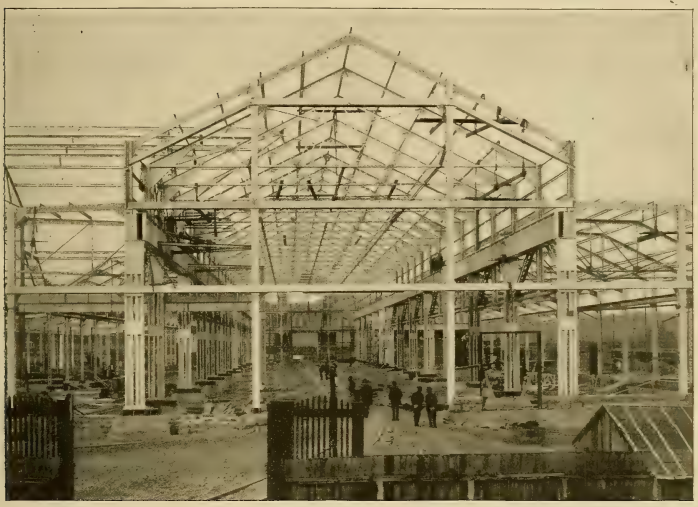
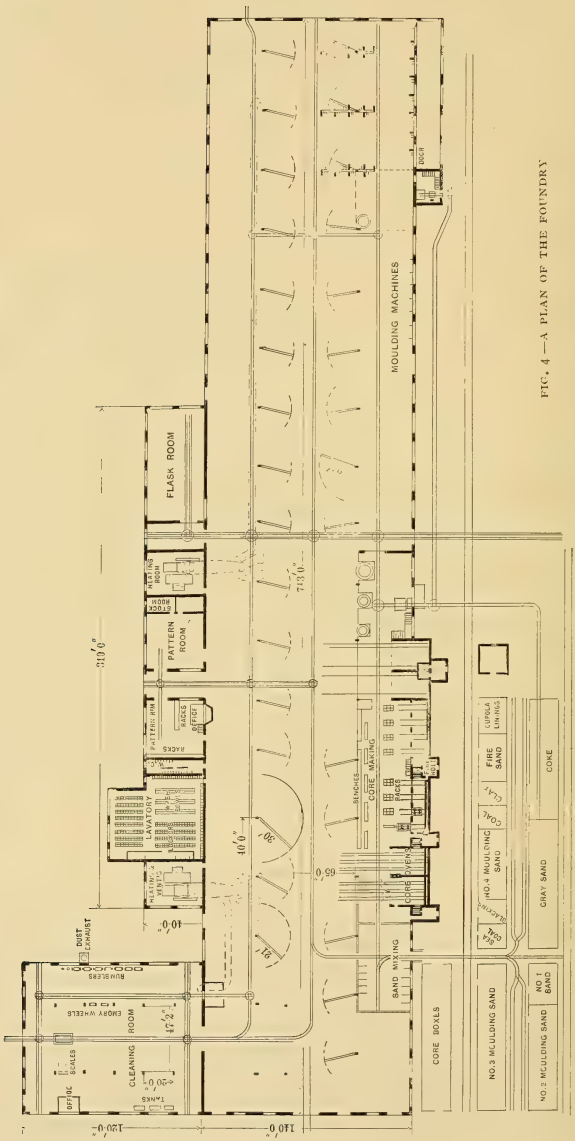


FIG 3.—THE STEEL FRAMEWORK

As a rule, the lighting and ventilation of a foundry are the least considered points, as the general idea has been that moulders are supposed to be employed at dirty work. Visitors on entering this foundry, however, are impressed with the abundance of light, which affords a strong contrast to the dark and gloomy foundries ordinarily seen. On each side of the roof over the main bay there is a strip of wire glass, 22 feet wide, running the whole length of the building, which, with the large and numerous windows in the sides and ends, gives a splendid overhead light. The windows furnish 11,500 square feet of light, and the wire glass in the roof furnishes about 30,000 square feet, making a total of 41,500 square feet of light for 103,600 square feet of floor space in the main building. The results show that there has been a proper proportioning of light area to floor area.

The building is equally well lighted at night by sixty-five arc lamps which are distributed so as to give the best results, shown by the fact that when these lamps are turned on shortly after sunset on a clear winter day, the moulders detect no diminution in light as night comes on. In addition to this general illumination provision has been made for the use of incandescent lamps with long leaders, which can be used in setting cores and doing other work, so that faults in castings cannot be attributed to lack of good light.

The heating of the building is accomplished by the warm blast system, two


FLASK ROOM
MOULDING MACHINES
PATTERN ROOM
CORE MAKING
SENCHES
CORE OVENS
SAND MIXING
CORE BOXES
NO.3 MOULDING SAND
NO.2 MOULDING SAND
NO.1 SAND
GRAY SAND
COKE
FIRE SAND
CUPOLA LININGS
CLAY
NO.4 MOULDING SAND
CRANE
CRANE
CRANE

blower rooms being located at different points in the lean-to, each containing steam coils fed by exhaust steam from the central power station. One of the blast wheels is 7 feet wide and 14 feet in diameter; the other measures 6 feet wide by 14 feet in diameter. Both are driven by variable-speed electric motors.

During the coldest days of winter, with the thermometer outside at zero or even lower, the temperature within has never been below 50° F. During the summer months the steam is, of course, cut off, and the blast wheels are operated at slow speed when pouring off and when "shaking out" the castings; on very sultry mornings, too, the smoke and dust can be forced out by the air blast through the monitor windows, which are made to swing horizontally and are controlled from the floor by a very convenient arrangement. In addition to this, constant ventilation is maintained by means of fourteen 60-inch circular ventilators placed in the peak of the roof.

The general arrangement of the foundry and sheds is shown in the plan on the page opposite. It will be seen that the main portion of the building is devoted to the moulding floor, the heavy work being in the middle bay, which is 65 feet wide. On the right are the sand mixing, core making, core baking, and cupola rooms, and moulding machines, the latter having been lately introduced and having superseded nearly all hand bench work. In the side bay on the left the medium work is done, and in the lean-to on the same side will be found the heating and ventilating plants, and the lavatory and locker room, shown in part on page 299, which is large and well-ventilated and contains eight shower baths, enabling the moulders to put themselves in presentable condition after "pouring off," and to go home feeling clean and refreshed after their day's work. The lockers are made of wire and expanded metal, and are so arranged that they can be inspected at all times, and can be thoroughly washed down with the hose at desirable intervals and kept in a sanitary condition. There are at present 600 lockers in the room.

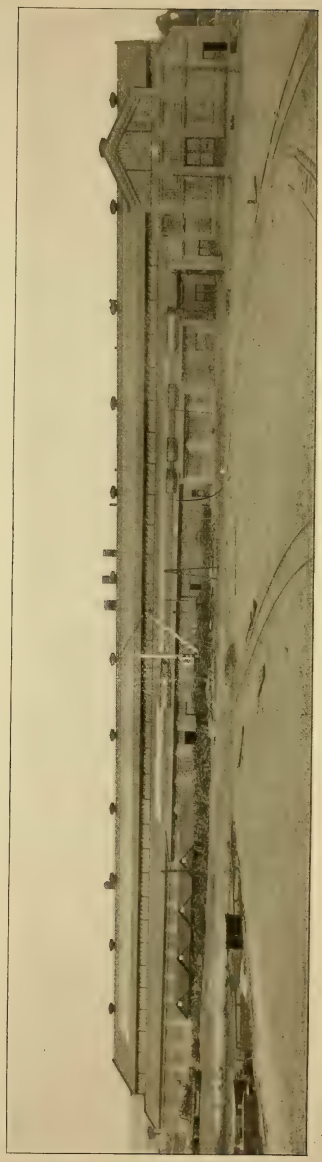


FIG. 5.—THE COMPLETED FOUNDRY

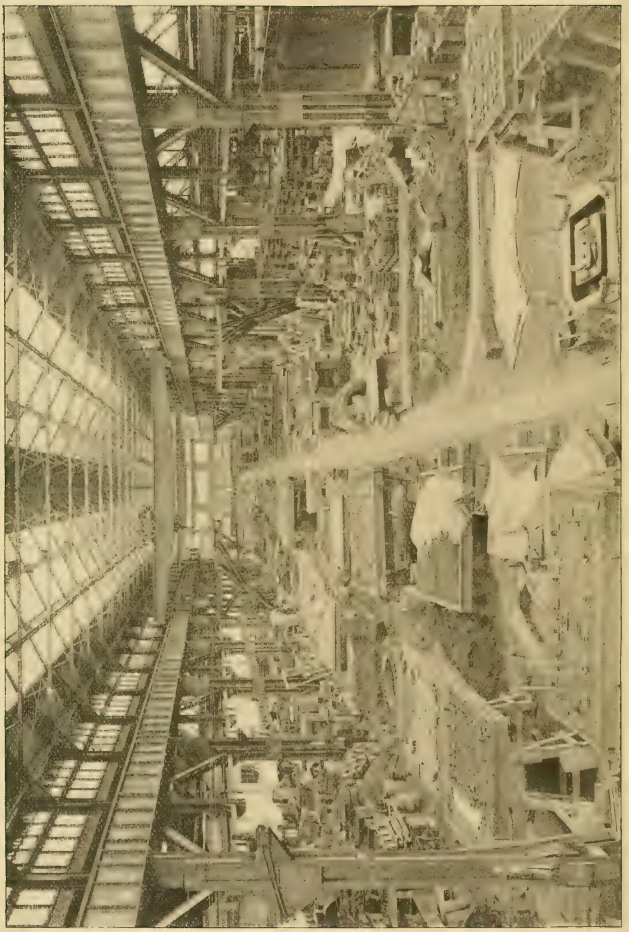


FIG. 6.— A GENERAL VIEW OF THE INTERIOR

The lean-to also contains a flask-making room, where all flasks, wood and iron, are made and repaired, and where, as well, minor repairs to patterns in active use are carried out. Important repairs and changes in the patterns are made in the pattern shop proper, located in another building near the iron foundry. Near this flask-making room in the same lean-to are two pattern storage rooms where patterns are stored temporarily, waiting for the necessary routine which will put them into the sand. In one of these rooms a pattern clerk is located, who keeps track of all patterns going into the foundry and of those coming out, of the moulder using them, the number of castings ordered, and the piece price for moulding.

A separate wing is provided for the cleaning, chipping, and weighing of the castings and for the proper distribution to the various machine departments of the works. As soon as the castings are "shaken out" they are taken from the main portion of the building and sent to this wing, so as to leave the entire moulding floor free for moulding work. There are seven exhaust rumblers in this room, the exhaust carrying off a large part of the dust to the outside of the building into a suitable receptacle. An exhaust sand blast is also used in connection with the work of this room, and its use assists very materially in the proper cleaning of the castings.

Transportation facilities in any large shop are of prime importance, especially in an iron foundry where such a variety of castings and material in bulk have to be handled and distributed to the various parts of the building. In this instance the crane system and the system of tracks throughout the foundry provide for the prompt and economical handling of all the material. In the main bay there are four travelling cranes, of forty, thirty, fifteen, and ten tons capacity, the forty-ton and thirty-ton cranes being equipped with a five-ton auxiliary hoist. In the side bays are seven travellers, of five and seven tons capacity. These all are three-motor cranes, and are fitted with cages for the operators in the same way as the large travellers. The cleaning wing has one ten-ton traveller in the centre and three hand travellers in the side bays for the handling of small castings.

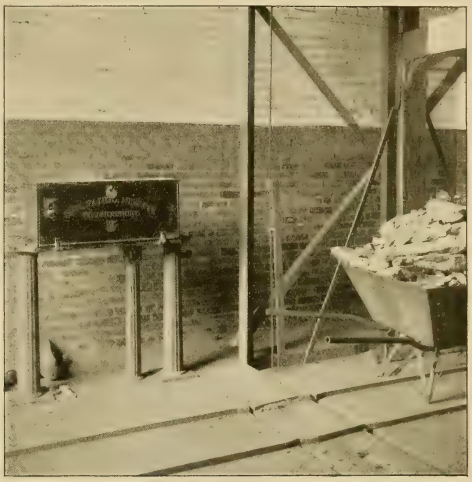


FIG. 7.—THE ELEVATOR TO THE CUPOLA CHARGING FLOOR

All the columns in the main bay, supporting the roof and the crane girders, are fitted with pintles for the placing of the jib cranes, which are of five tons capacity and use electric power. They are of different swings,—20, 25, and 30 feet,—and are important auxiliaries in the handling of the work. The novel feature about them is their mobility, as they can be lifted from one column by one of the large travellers and carried to another column where they may be wanted. The entire change is made in from five to seven minutes, and this includes making the electric connections.

FIG. 8.— TRANSFERRING A PORTABLE CRANE FROM ONE POST TO ANOTHER BY MEANS OF ONE OF THE OVERHEAD CRANES

Fig. 8 shows one of these cranes being shifted. By this arrangement a comparatively few jibs, nine, in fact, serve the entire foundry, and many of the moulders can work without interruption even in the afternoon while the large travellers are engaged in carrying the molten metal for "pouring off." There are also several light jibs for use in connection with pneumatic hoists.

This extensive crane system is supplemented by tracks, of 21½ inches and 36 inches gauge, which connect portions of the main building, sand, and coke sheds, pig and scrap iron piles, and the flask storage room, so that the flasks, copes, and all other needed material can be easily conveyed to any part of the building. For instance, a ladle of molten metal is picked up in front of the cupola by one of the large travelling cranes and is carried to a point where a track crosses the building, placed on the 36-inch gauge cars, which serve as a transfer, and is run into a side bay. There the ladle is lifted by one of the side travellers, is carried to the moulds and is poured. The reverse of this operation

is done when the castings are "shaken out" and carried to the cleaning wing. This system of tracks will probably be better understood when it is stated that 6400 feet of 21½-inch gauge, 1700 feet of 36-inch gauge, and 4400 feet of 56½-inch gauge have been installed in and about the foundry for the handling of raw material and castings and foundry dirt.

There are four cupolas of the Colliau type,—three in the original building and one in the addition. These cupolas have a capacity of seventeen, eleven, seven, and twelve tons per hour, respectively. Two rotary pressure blowers supply the air blast. One is connected with the group of three cupolas and is driven by a 60-H. P. belted electric motor. The air from the twelve-ton cupola is furnished by a similar blower driven by a 50-H. P. belted motor.

The charging floors have large areas, and a sufficient supply of pig-iron and scrap can be carried on them for two heats. The pig-iron, scrap, and coke are conveyed to the charging floor by electric hydraulic elevators, and are weighed on scales placed just in front of the elevator (Fig. 7). An ample supply of ladles is provided, as shown by the following list:—

1	15 tons.
1	10 "
1	8 "
1	6 "
—	5 "
1	4 "
1	3½ "
2	1½ "

There is also a full supply of track ladles and hand ladles. No difficulty, therefore, is experienced in pouring very large castings.

By referring again to the plan of the foundry on page 294, it will be seen that the core making covers one side bay, occupying a space 300 feet long by 36 feet wide, and includes the mixing of the core sand and the facings, and the baking and the storage of the cores, for which ample rack capacity is provided.

The oven equipment, too, is ample, there being three of the well-known Millett ovens for small cores and six ovens of medium size, the cars of which are operated in a novel manner by compressed air. A 6-inch cylinder is fastened to the floor in front of each car, and the piston rod is fixed to the car it-

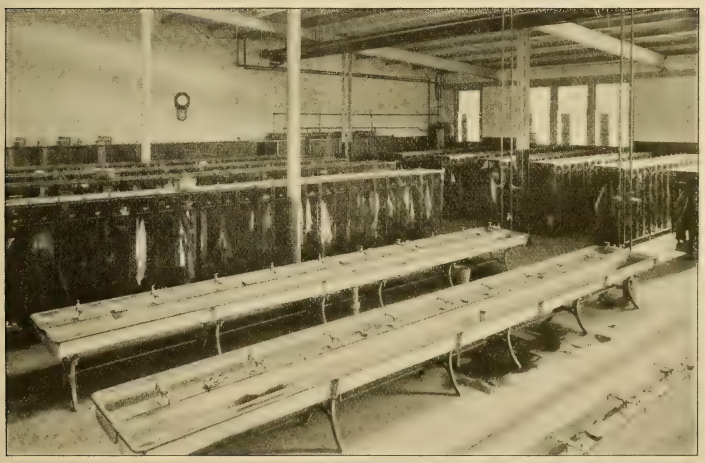


FIG. 9.—A CORNER IN THE WASH AND LOCKER ROOM

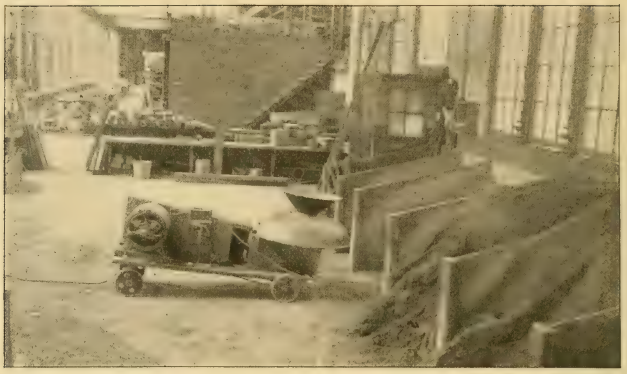


FIG. 10.—A PORTABLE ELECTRICALLY DRIVEN SAND MIXER

self, the movement of the car being controlled by a three-way valve. Another novel feature of the car is that its ends are practically the doors of the oven, so that the latter is closed when the cars are either in or out, and escape of heat is minimised. One of the ovens, being opened, is shown in Fig. 15. The facility with which these cars are operated allows the cores to be in the oven most of the time, as little time is lost in backing the car out, loading on the green cores, and running them back into the oven again.

An electric motor equipment, in the shape of a Sellers centrifugal mixer and a double Gould-Eberhardt sifter, is provided for mixing core sand, facing, etc., both machines being mounted on trucks, as shown in Figs. 10 and 11, so that each outfit is complete in itself. By means of flexible cables for the electrical connections, these outfits can be placed alongside of any bin and operated, so that the handling of the sand in its preparation for the moulders or core makers is reduced to a minimum.

Further along in this same side-bay is the group of three cupolas. Then we reach that part of the building devoted to moulding machines, comprising the largest installation, perhaps, that can be found in any similar foundry anywhere. Forty-six machines are in daily use, the sizes being from 12 inches × 15 inches to 48 inches × 84 inches, and castings from these machines vary in weight from 1 pound to 1100 pounds. As many as 225 flasks are frequently taken from one machine daily. About 75 per cent. of the casting orders that come to the foundry for these machines call for less than 100

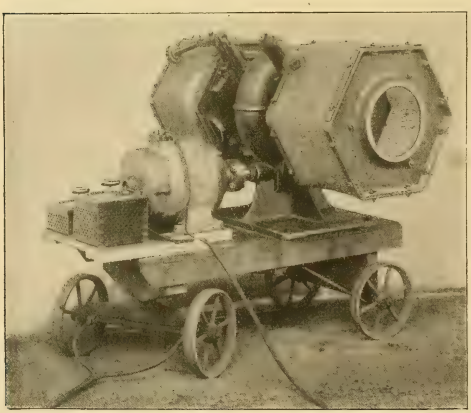


FIG. 11.—ONE OF THE PORTABLE SAND SIFTERS

castings from one pattern, and many of them call for from six to ten. The production of castings for such orders has been successfully handled on these machines by the introduction of wooden patterns and the use of paraffine moulding boards, the latter being original with this foundry. In some instances fifteen changes of patterns have been made on one machine in one day. On account of their uniformity, castings from these machines can be made to come closer to their finished dimensions than hand-moulded castings, and much work is, accordingly, saved in the machine-shop operations.

Moulding machines are now regarded as valuable adjuncts to a foundry, and within the last few years they have received considerable study. They are now used wherever a considerable number of castings are of a repetitive character, the advantages being castings of greater uniformity, increased product, and economy in time and cost. In order to reduce the amount of hand carriage of metal for the flasks put up on these machines an overhead track has been installed, as shown in Fig. 16.

The entire building is piped for compressed air, which is used in the operation of the moulding machines, pneumatic hoists, pneumatic chippers, pneumatic sifters, and core cars. For skin drying some of the larger moulds and copes in position, three portable hot-air furnace sets are used, as shown in Fig. 13. Each of these consists of a portable electric fan or blower set, which is placed near the mould to be dried. The blast of air from this is carried to a coke stove having an annular ring around the fire; in this the air is heated and is then forced down into the mould. The drying is done quickly and uniformly.

A summary of the entire motor equip-

FIG. 12.—READY TO SAND-BLAST CASTINGS

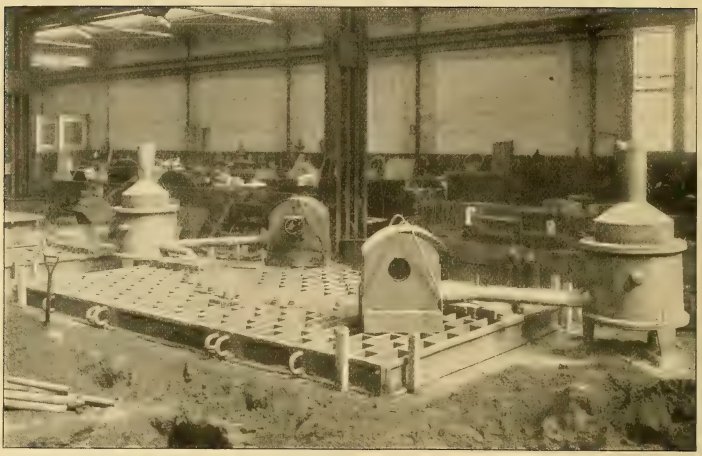


FIG. 13.—PORTABLE HOT AIR FURNACES FOR DRYING MOULDS

FIG. 14.—A PORTION OF THE PATTERN SHOP

ment of the foundry might be interesting, and is as follows:—

2—	1 H. P.
9—	2 "
9—	3 "
4—	5 "
16—	6 "
1—	7 "
1—10	"
1—15	"
3—20	"
11—25	"
4—35	"
2—50	"
1—60	"
2—80	"
1—85	"

The cost of electric energy used in any large foundry might be estimated when it is stated that the average energy used per month in this foundry is 23,000 kilowatt-hours. This includes the energy used for all motors and for the lighting of the building sheds, as well as the grounds about the building.

To handle and control all these various appliances and to perform the manual labour incidental to the work, about 725 men are employed, of whom 360 are moulders, helpers, and apprentices; 70 are core makers; and the balance are chippers, labourers, and helpers. One foreman and his assistants supervise the moulding, melting, and pouring. A manager attends to the ordering of materials, casting orders, the piece price, the storage of patterns, and the cleaning, weighing, loading, and shipping of the castings. An intercommunicating system of telephones, which connects the foundry office with the headquarters of the different assistants, has been installed, and aids very materially in the prompt transaction of the business of the foundry. The works management treats the foundry as a separate and distinct department, and it bears its proportion of all charges, such as interest, taxes, insurance, and the expense of general supervision. It is also charged with the amount of electric energy used, as read each month by recording wattmeters, so that, with the cost of all labour and material charged, the exact cost per year for producing castings is known to a certainty.

FIG. 15.—THE CORE OVENS

The weekly output of the foundry averages more than 550 tons of cleaned castings, which, however, is, at the present time, insufficient for the needs of the Schenectady works, and orders

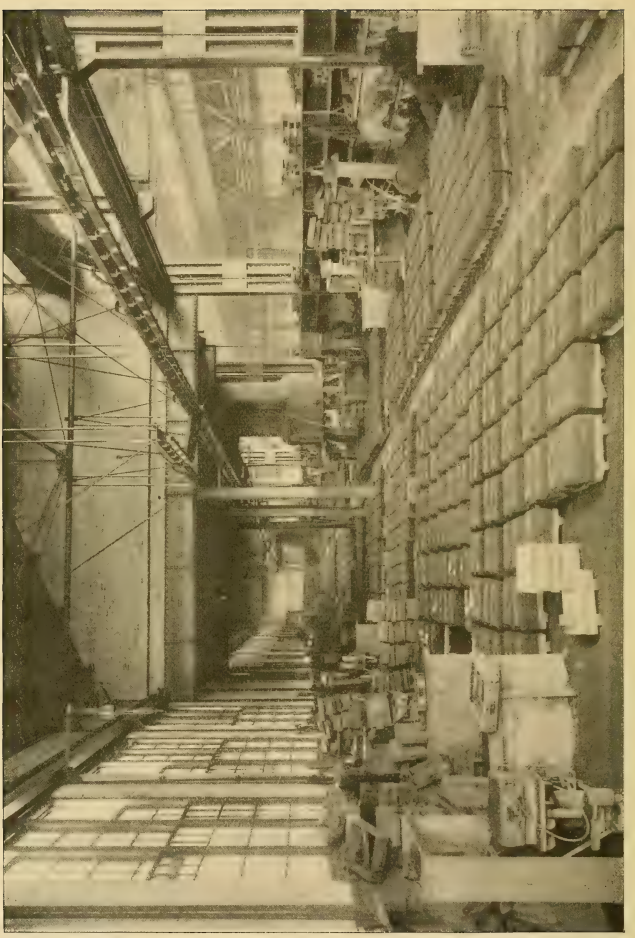


FIG. 16.—THE MOULDING MACHINE SECTION

are being placed with other foundries. The size and variety of the castings produced is probably greater than in any of the ordinary jobbing foundries, and an unusually large amount of cored work is done, which reduces the tonnage output. All the work is done in green sand. A good example of the smallest castings is a resistance grid measuring ⅛ inch in thickness and weighing one pound, while the largest ones run to a driver for revolving field 15 feet in diameter and weighing twenty tons. As the making of new patterns and the repairing and changing of old ones for such a large foundry is necessarily closely allied to the pattern shop, this description would be incomplete without a brief reference to the pattern shop here provided. This is located in a three-story building, 64 feet × 290 feet, the third floor being devoted largely to storage. Fig. 14 gives a very good idea of one portion of the shop, in which 155 pattern makers' apprentices and labourers are employed, and in which, as well as in the foundry, every resource looking toward the economy of pattern making is brought into service.

DANGERS FROM ELECTRIC TROLLEY WIRES

AND OTHER AERIAL CONDUCTORS

HOW THEY ARE GUARDED AGAINST IN GREAT BRITAIN

By Professor Andrew Jamieson, M. Inst. C. E.

ABOUT a year ago a large number of telephone wires in Liverpool fell upon a trolley line and resulted in the electrocution of two men and two horses, as well as the electrification and injury of a dozen persons. A few days later "a cluster of electric light wires in Princes Road, Liverpool, lodged on the tramway trolley wire, causing the breakage of the electric lamps in the vicinity." Again, in the same city, "a trolley head fouled a span wire and broke it, so that it came into contact with the trolley wire and with the ground, thus causing alarm to the passengers and pedestrians, due to the heavy sparking and arcing."

It is needless to multiply these examples, for scarcely a week or even a day passes that we do not notice accounts of one or more different kinds of accidents, arising from the contact of overhead conductors with trolley wires. These accidents prove that so long as telephone, telegraph, and electric light wires are permitted to cross over electric tramway routes there is a liability to their occurrence; and further, that we still lack a perfect system of guarding trolley wires from accidental contact with other conductors. There are also dangers arising from the fracture of the trolley wire and its contact with the guard wires, persons, or animals, as well as the delay and disturbance to traffic arising therefrom.

Telegraph and telephone aerial conductors have increased so gradually, and existed so long in our cities without causing serious mishaps to the public, that the British Government have, no doubt, felt unwilling to apply such stringent rules to these lines as they did in the case of "overhead electric light and power wires," and are now doing with "electric tramway conductors." Nevertheless, the Board of Trade, in attempting to remedy one evil, have introduced a new one, in the form of guard wires.

Most of the telegraph and telephone lines which cross our busy streets belong to the government, or pay royalty. Hitherto these wires have frequently been erected with longer spans and at more acute angles to the thoroughfares than might seem judicious. The reasons for such departures from sound engineering practice were, no doubt, due to the difficulty of obtaining the necessary safe supports and wayleaves on the roofs of a sufficient number of strong buildings in line with the desired destination. When these wires broke, due to decay, storms, or fires, no great harm arose. But, with the introduction of the bare live trolley wires, fatal accidents have become so common from the breakage or down-coming of overhead conductors that the Board of Trade have had to step in and enforce rules which throw the onus of guarding the trolley wires upon the tramway corporations. The latter, naturally, object to some of these restrictions; and at this very time an interchange of opinion is taking place, with a view to formulating a new set of rules which may be more acceptable, and at the same time more efficiently guard the public against possible dangers. Consequently, several kinds of trolley wire guards have been proposed and tried, and a few of these, together with the hitherto ruling Board of Trade

A VIEW OF EGLINGTON TOLL, GLASGOW, SHOWING FITTINGS AND CONNECTIONS FOR OVERHEAD TROLLEYS

SOME OVERHEAD GLASGOW WIRES

Regulations, are illustrated and described here.

Figs. 1, 2, and 3 show the wooden guard strip systems which have hitherto been and are now being tried in Liverpool. These consist of strips of wood, machined to the shapes shown by the cross sections, and supported by metal distance pieces, or clips, which are fastened to the upper surface of the trolley wire at convenient intervals. Although one of the cheapest, and perhaps one of the least unsightly guards in use, its inefficiency as a safeguard against fallen springy bronze telephone wires was demonstrated by the Liverpool catastrophe mentioned at the beginning of this article. The dotted lines on the cross section and longitudinal view of Fig. 2 serve to indicate how broken telephone wires do curl and make contact with the trolley wire. Or, they may be dragged into connection with it by a passing vehicle or car. In fact, to prevent the trolley wire current entering any of the fallen overhead conductors the broken wires must clear the trolley wire and remain free until repaired, and the insulation resistance of the wooden strips would require to be great under all atmospheric conditions. But such assumptions are most unlikely of fulfilment in stormy or snowy weather, and where there is considerable traffic.

Such wooden guard strips have been tried and abandoned at Bradford for the very reasons which have just been given, and the Liverpool Corporation have arranged that all telephone lines shall be put underground by September, 1902. The wooden guard strips, it should be noted, moreover, do not comply with one of the rules which is being most urgently requested by the Board of Trade, namely, that all trolley wire guards shall be duly connected to earth at frequent intervals.

Combined recent inspections have been made by the Post Office and the Board of Trade electrical engineers, with the view of formulating a new joint set of rules, but as these have not yet been issued to the public in a definite and agreed-upon form, we must, of necessity, refer solely to extracts from the hitherto authorised copies.

1.—When there is only a single trolley wire or when there are two trolley wires not more than 12 inches apart, two guard wires should be erected, as shown in Figs. 4 and 5.

2.—When trolley wires are more than 12 inches apart, and do not exceed 3 feet, the guard wires should be increased to three in number, as shown in Fig. 6.

3.—When the distance separating the trolley wires exceeds 3 feet, each wire

should be separately guarded by two wires, as shown in Fig. 7.

If these Post Office regulations were faithfully and carefully carried out, there can be no doubt that the chances of broken telegraph or telephone wires coming into contact with the tramway trolley wires would be minimised. But tramway contractors and companies, or corporations, as well as the general public, may be expected to object to the multiplicity of such wires so near to the roadway, their liability to become inextricably mixed up in the case of an accident to one or more of them, and also on æsthetic grounds.

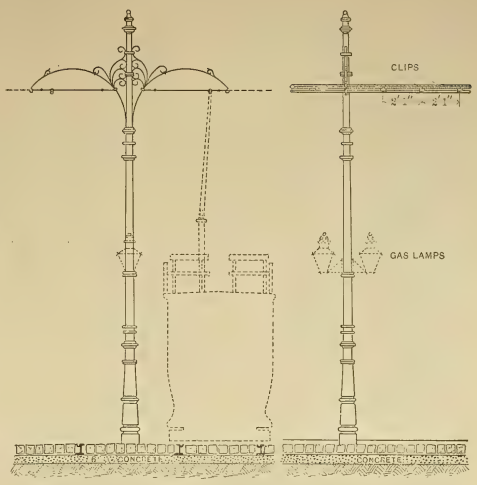


FIG 1.—OVERHEAD CONSTRUCTION AS RECENTLY ADOPTED AT LIVERPOOL

The two methods of arranging the guard wires which have been tried in Glasgow and many other installations are shown in Figs. 8 and 9. Wherever telephone or other wires are suspended above and across the trolley wires each of the latter is guarded by one No. 7 S.W.G. galvanised steel wire, carried parallel to and about 2 feet above the live car wires. At first, these guard wires were insulated and placed from 8 inches to a foot to the left and right of the respective trolley wires. Now, however, they are earthed at the feeder pole of each half-mile section, and sometimes even more frequently. For the most part they are placed vertically above the trolley wires which they are intended to protect, as in Fig. 9. But, as has been proved in actual practice, and as is shown by the dotted lines in both figures, the fallen springy telephone wires do make contact, not only with the guard, but also with the trolley wires.

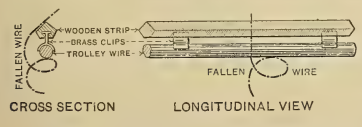


FIG 2.—GUARD SYSTEM HITHERTO TRIED AT LIVERPOOL

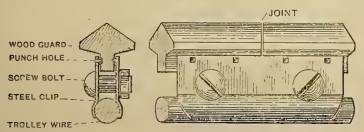
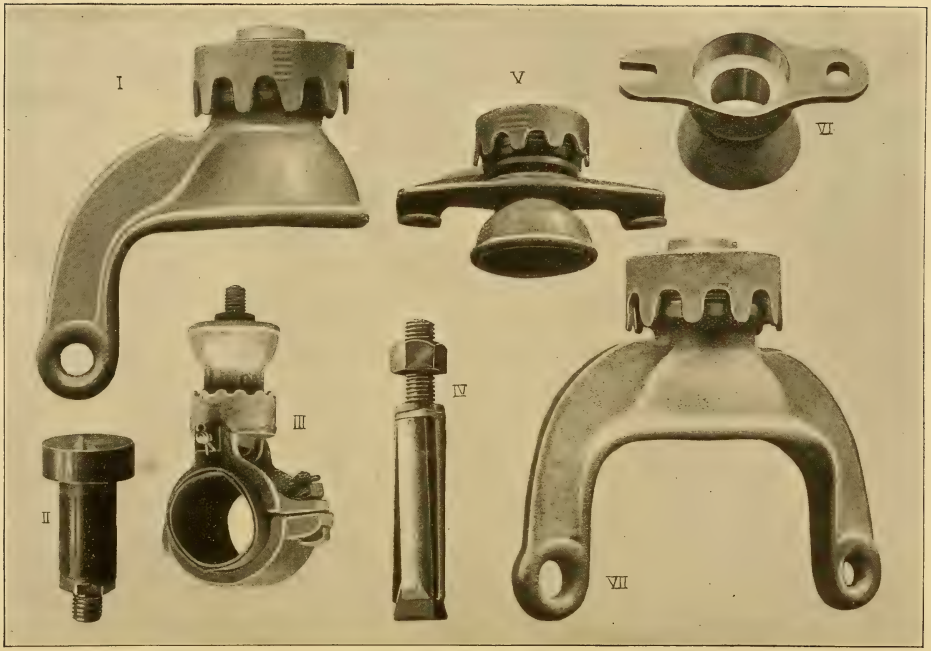


FIG 3.—GUARD SYSTEM NOW BEING TRIED AT LIVERPOOL

When the former were insulated, the current from the latter entered the fallen wires, and was, therefore, not only a great source of danger to passing human beings and animals, but has been known to blow fuses, or destroy telegraph and telephone receivers, and even to set fire to telephone stations in which there were either no protecting fuses or inefficient ones. When the guard wires are properly earthed, the short piece of contact-making, fallen wire is expected to melt almost instantaneously and its street end to fall harmlessly to the ground. This may happen without affecting the fuses or the automatic cut-out switches at the tramway stations, or even the section pillar boxes. In the case of a large number of overhead conductors simul-



I, SINGLE CURVED HANGER; 2. INSULATED BOLT; 3, PIPE BRACKET HANGER; 4, LEWIS BOLT AND WEDGES; 5 AND 6, HANGERS; 7, A DOUBLE-CURVED HANGER

TROLLEY WIRE FITTINGS ERECTED BY MESSRS. MACARTNEY, MC ELROY & CO., LTD., OF LONDON AND GLASGOW, FOR THE GLASGOW CORPORATION TRAMWAYS IN 1901

taneously making contact with the guard and the trolley wires, these safety devices are expected to act and thus render the trolley wire of the section neutral and harmless. Telegraph and tramway engineers hold somewhat opposite views in regard to the advantages and safety arising from the insulating *vs.* the earthing of guard wires, but the new Board of Trade rules will finally settle this question.

FIG. 4.—ONE TROLLEY WIRE

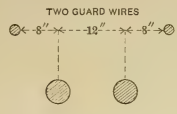


FIG. 5—TWO TROLLEY WIRES NOT OVER 12 IN. APART

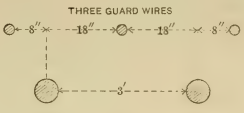


FIG. 6.—TWO TROLLEY WIRES NOT OVER 3 FT. APART

It was stated at the beginning of this article that dangers arise from the breaking of the trolley wire or of the guard wire, as well as from contact between them. The chief and the primary causes of such contacts and breakages arise from:—

1.—The omission to turn the trolley pole at the end of a tramcar line in the proper slanting direction for the return journey, or whenever the direction of the propulsion of a car has to be reversed. The neglect of this precaution often unships the trolley pole from the trolley wire, and permits the former to foul the guard wire or its cross street span wire, thus severing the binding between the latter two wires, or breaking the guard wire.

2.—Unshipment of the trolley pulley at street corners where the ears are too short, or the frogs and the cast bronze brackets at crossings, are badly adjusted.

3.—Disconnection between the trolley wire from hangers, splicing ears, or sectional insulators due to their imperfect soldering and clipping; or, due to the breaking of ears, and of the trolley wire at the pinching pins of bracket crossings.

4.—Fusing of the trolley wire due to intermittent contact and arcing between it and a disconnected guard or span wire.

The writer is of the opinion that guard wires and their bindings should be made of mild silicon bronze or hard-drawn copper, instead of the usual galvanised steel. Such wires would be stronger for the same size, and would not only have greater conductivity, but they should withstand the rapid, corrosive effect which grimy, chemical-laden atmospheres have upon galvanised steel wires.

It is seldom that the trolley wires break from over-tension arising from poor erection, or even from fouling the trolley poles. They are usually composed of the very best hard-drawn 98 per cent. conductivity copper, having a diameter of 0.37 inch, which is equivalent to No. 000 S.W.G. or fully 00 B. and S. gauge. The initial stress which this wire will withstand before beginning to stretch is over 54,000 pounds, or twenty-four tons per square inch of the

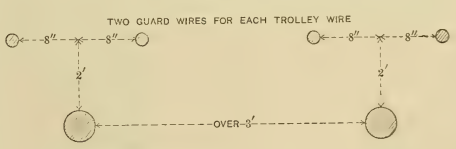


FIG. 7.—TWO TROLLEY WIRES, OVER THREE FEET APART

FIGS. 8 AND 9.—GUARD WIRES AS ADOPTED AT GLASGOW

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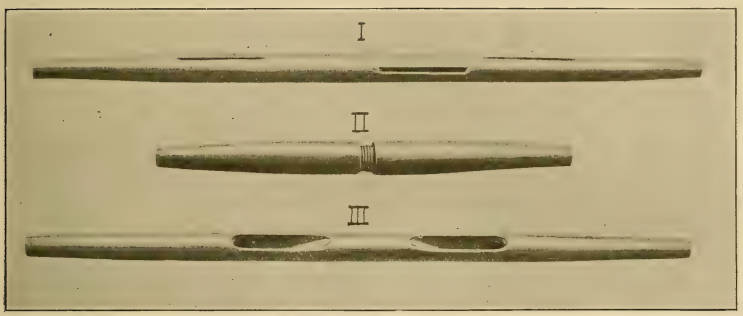
A VIEW OF GLASGOW BRIDGE WITH OVERHEAD TROLLEY WIRES

full section. But when subjected to a continuous steady pull, the very small elongation of 4 per cent. is accompanied by a gradual diminution of the original cross area of fully 40 per cent. In any case, there is comparatively little chance of the trolley wire being broken by an accidental stress, except at the pinching pins of crossings and where it becomes rapidly worn at sharp street curves. Special watchfulness is, therefore, necessary at such curves and crossings, in order that the wires may be renewed before they become unduly reduced in size.

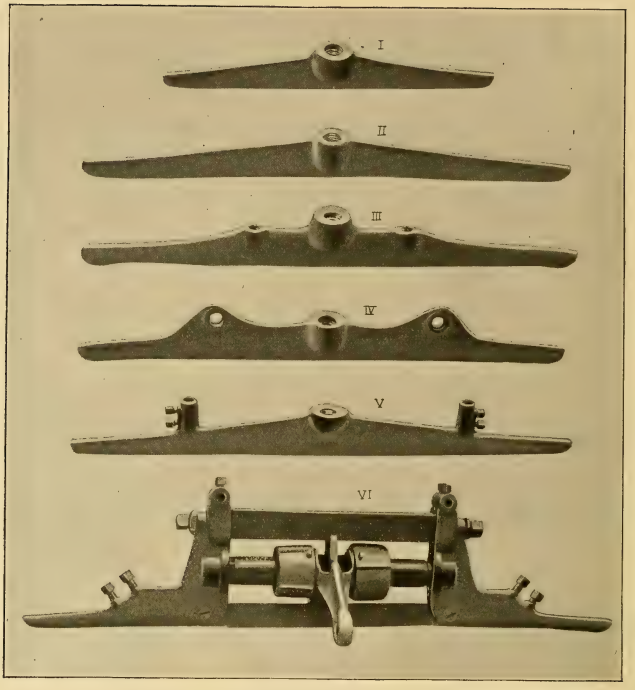
Assuming that the trolley and guard wires are made of the best materials, erected in the most substantial manner, divided into separate half-mile sections, and supplied with current direct from the power house, or from a sub-station, it is, nevertheless, most desirable to be able to render any such section inoperative or "dead" as soon as possible after any one of the previously mentioned faults occur in it. When this has been effected, the section can be handled and repaired with impunity, and no further danger from it need be feared, except that due to a delay in the traffic until the current is reapplied. Many devices have been proposed and adopted with this object in view, and of these the following may be mentioned:—

1.—Automatic cut-out switches at the supply stations. If several half-mile sections are supplied with current through one cable from a station, then these switches will not act unless an abnormal current is demanded by a short-circuit or something approaching thereto.

2.—Fuses or automatic cut-out switches, or simply hand-switches, in each of the half-mile street pillar switch-boxes. There should also be a telephone, or connections for one, in each of these boxes, communicating directly with the current supply stations and the engineer's office. It is not usual, however, to place fuses, or even automatic switches, in these pillar boxes, for most tramway engineers object to multiplying such devices. They, therefore, simply insert in them a main feeder hand-switch and a trolley wire section hand-switch for each car line, plus a telephone wire connection. Moreover, keys for opening these boxes are, as a rule, given only to the engineering staff, and consequently neither the car driver, nor the conductor, nor the car inspectors can operate these switches in case of an accident to any particular section. All that they can do under the circumstances is to use their insulating gloves and pliers, or "earth" a fallen wire to the rails, and communicate with the head office from the nearest special telephone pillar. This roundabout proceeding causes an unnecessary waste of time and blocking of the traffic, as well as a possible cause of danger to passengers and animals.



TROLLEY WIRE CONNECTORS AND SPLICING TUBES



1 AND 2, STRAIGHT LINE EARS: 3, A SPLICING EAR; 4, AN ANCHOR EAR; 5, A FEEDER EAR; 6, A SECTION INSULATOR
SOME MORE TROLLEY WIRE FITTINGS ERECTED BY MESSRS. MACARTNEY, MC ELROY & CO., LTD, FOR THE GLASGOW CORPORATION TRAMWAYS IN 1901

"In a recent case a cart horse, which had been stunned and brought to earth by a shock from a broken, hanging guard wire that was charged by contact with a trolley wire, lay on the ground with the live wire underneath him, searing his hide, for about a quarter of an hour, simply because none of the drivers or conductors could open the street switch-box, which was close at hand, and turn off the current from that section. Why not supply these employees with keys, and give each of them clear printed instructions how to act under certain circumstances? This latter plan has just been successfully carried out at Bradford, without any apparent mistakes being made, and delay to the traffic is thus minimised.

3.—"Earthing devices" may be attached to either a bracket arm or to a trolley wire suspension. There are several kinds which act when the trolley and the guard wires break, or when overhead conductors fall across them, by short-circuiting the trolley wire to the tram rails. The objections to such automatic earthing devices are, complications, uncertainty in action, more supervision, due to the extra overhead and locked-up apparatus and wires, unsightly appearance, and the extra expense.

4.—Placing an earthing switch in each car. In the case of the severance or disconnection of the trolley or a guard wire, or a serious downfall of overhead conductors, all that the driver or the

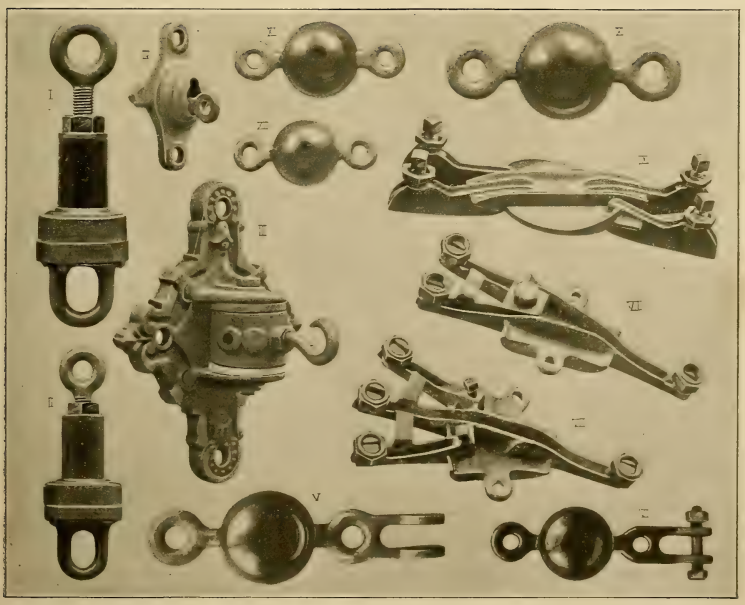
guard has to do is to break the glass front of a special box and turn a switch, or insert a plug in a metal hole, thus immediately earthing the trolley wire to the tramway rails through the trolley pole and car wheels. This operation instantly causes an abnormal current to flow in the feeder to the section in which the car happens to be at the time, and consequently frees its automatic switch at the station. This device, which is now being tried at Bradford and Leeds with satisfactory results, seems to be one of the simplest and most direct methods of rendering any section quite neutral in a minimum of time in the case of an emergency.

As regards the subject of aerial telephone and telegraph cables *vs.* underground wires or cables, it is to be noted that in several of the large cities of Great Britain there are now at least four authorities dealing with these important matters, viz.:—

1.—The Government Postal Engineering Department, who have placed some of their principal telegraph and telephone city wires underground, but who still have a large number of aerial wires.

2.—The railway companies, who still maintain many telegraph and telephone iron and bronze wires across tramway routes.

3.—The National Telephone Company, who have hitherto, for the most part, used fine bronze overhead wires, and wherever they are prevented from opening the streets, for the purpose of laying down underground cables, are now running aerial telephone cables. These cables consist of about 100 paper-insulated wires, twisted together and then insulated as a whole with canvas



1 AND 2, LARGE AND SMALL STRAIN INSULATORS; 3 AND 4, LARGE AND SMALL ROSETTES; 5 AND 6, GLOBE STRAIN INSULATORS; 7, A THREE-WAY FROG; 8, A Y-FROG; 9, A CROSS-OVER. 10, 11 AND 12, GLOBE STRAIN INSULATORS

and vulcanised india-rubber, protected by waterproof matting and strong woven tape. The cables are suspended by hooks hung from strong stranded steel span wires, attached to brackets fixed to the walls or the roofs of buildings. Two conductors are used for each closed telephone circuit, to avoid induction, etc. Such cables and their suspension spans are not likely to interfere with tramway trolley wires; and even if they did come down in the case of a fire, they are so large, well-insulated, and strong that they could be more readily dealt with than a similar number of bare, bronze, springy wires.

4.—The Corporation of Glasgow have just started a telephone exchange, and having full authority in regard to their streets, they have very properly taken the precaution to place all their city wires and cables in underground cast-iron pipes where they approach the tramway lines. Other cities are following their example.

In most of the towns and cities it will take time and cost a great deal of money before all the present overhead telegraph, telephone, and electric light conductors are placed underground, and consequently, in the meantime, the public and the tramway corporations are waiting in considerable expectancy for the Board of Trade's latest and best solution of a safe and handy trolley wire guard. But there cannot be the slightest doubt that the only safe and sure plan is to place all non-tramway wires of whatever kind underground. If this were done, there would be no necessity for guard wires, thereby leaving trolley wires, which have come to stay, free from extraneous contacts, and thus minimising the afore-mentioned dangers.

HOISTING MACHINERY

By Joseph Horner

HYDRAULIC WHARF CRANES, STEAM AND ELECTRIC JIB CRANES, LOCOMOTIVE CRANES, AND GENERAL SERVICE HOISTS

In the Opening Section of this Article in the January Number, Long-Range Cranes were Dealt with, of the Bridge and Transporter Types

THOUGH hydraulic cranes are not novel, their application has greatly extended in shops and on wharves, as the smoothness of their motion is a great point in their favour. In foundries, and forges, and boiler shops, in steel works and on wharves they become increasingly common. Special types are the great coal tips which will lift and tip a truck load easily, handling many truck loads amounting to several hundreds of tons, ranging from 300 to 700, in a single hour. It is certain that the increasing attention which is being given to the utilisation of water power will result in the erection of a greater number of such cranes and tips.

The tips of the South Wales ports handle enormous loads. Thus, at the four coal tips at Penarth Docks (see page 319), supplied by Messrs. Fielding & Platt, Ltd., the steamship *Galesgarth* came in at 8.10 on a certain day

TEN-TON HYDRAULIC CRANE IN THE YARD OF THE WALLSEND SLIPWAY AND ENGINEERING CO., LTD., NEWCASTLE-ON-TYNE, ENGLAND. BUILT BY MESSRS. FIELDING & PLATT, LTD., GLOUCESTER

LIFTING 100-TON GUNS AT SPEZZIA, ITALY, WITH AN ARMSTRONG HYDRAULIC CRANE

in the morning tide. After bunkering with one tip, she began taking in cargo at 9.15 A. M., finished at 11.50 A. M., and sailed on the same tide with a cargo of 2333 tons, taken aboard in two hours and thirty-five minutes. On another day the steamship *Bangarth* entered the dock at 11.45 A. M. and took in 50 tons of bunkers from one tip in eight minutes. By 11.55 she came under the four shoots, and by 1.55 P. M. was loaded with 2154 tons of cargo.

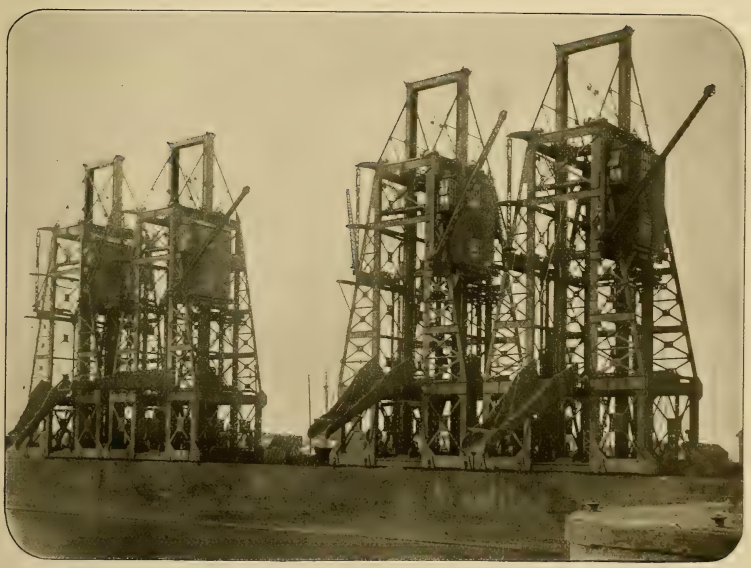
The action of these tips, in brief, is this:—The loaded ten-ton railway waggons are run underneath them on a cradle which is elevated by means of hydraulic rams. The cradle is in two parts, the main portion and a tipping portion, which is hinged next the dock. The shore end is tipped by wire ropes. The rams are 45 feet long, and the cradle is elevated to that distance, and then discharged into the shoot of the tip. A waggon can be raised, tipped, lowered, and run off in thiry seconds!

Mobility is provided for to suit the hatchways of different vessels by pivoting the shoots so that they have a lateral adjustment of 5 feet each side of the centre at the tip, or 10 feet in all. The walking pipes also provide for a range of 15 feet both to pressure and return mains, so that either tip may be moved this distance without uncoupling the pipe attachments. There is thus a total lateral range of 25 feet possible to the tips. The height at which tipping shall be done is fixed automatically after the first waggon-load is discharged, by a pointer which shuts off the pressure and indicates to the attendant the moment for tipping.

Two systems have thus come into rivalry for dock, harbour, and wharf work, in shipyard and in iron ore mines, —the fixed and the travelling cranes. Examples of the former range from the fixed post cranes and the fixed coal tips

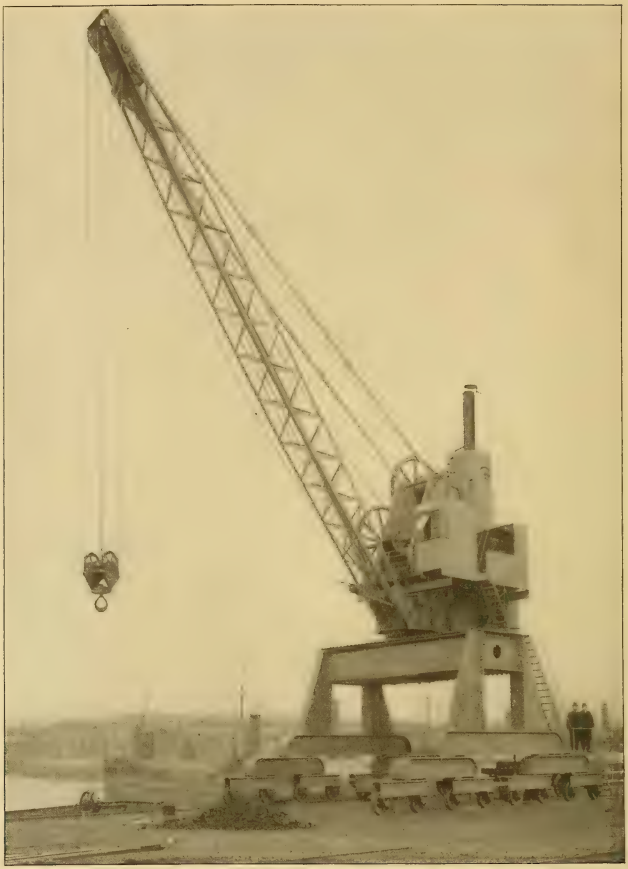
to the Armstrong hydraulic cranes and those of steam-driven type. Examples of the latter are the travelling gantry cranes with jibs, and the Brown cranes, and the Temperley transporters. The first-named types lift heavy loads slowly; the second hoist light loads at a high speed, and so get over a large volume of work, besides which their range is much greater. And they have the added advantage of mobility, which is of great value in many cases, because it is often easier to bring a crane to a ship and to vary its position in regard to the load than it is to reverse the process. And as the electrical conductor gets over the difficulties incidental to the use of jointed steam or water pipes, or to coupling up cranes at certain spots to these pipes, the result is that these cranes have multiplied rapidly in recent years.

In the crane type proper,—meaning by that the jib crane,—the self-contained engine and boiler predominate, as they did twenty or thirty years ago. The advances which have been made here are not less apparent in the smaller and cheaper than in the big, costly cranes. A twenty or thirty-ton jib crane was considered a large one fifteen years ago. The biggest jib crane in the world, that at Chatham Dockyard, was erected less than ten years ago. It weighs about 500 tons, and lifts 160 tons to a height of 50 feet. It is a combined steam and hydraulic crane, and lifted 320 tons at its test load. Another big steam jib crane, not yet ten years old, is in service at Finnieston Quay, Glasgow. This is of 130 tons power, and it weighs 370 tons. Six 5-inch bolts hold it to its foundations. The jib alone, 90 feet long, built of steel tubes, weighs, with its rods, 45 tons. Other steam cranes of nearly the same powers are located at various ports, at Belfast, for example, at Liverpool, and others.



COAL TIPS AT PENARTH DOCKS, INSTALLED BY MESSRS. FIELDING & PLATT, LTD., GLOUCESTER

Another feature in the later developments of steam jib cranes is the growing demand for those of small size. Cranes



A 25-TON STEAM TRAVELLING CRANE AT PRINCE'S DOCK, GLASGOW. BUILT BY MESSRS. GEORGE RUSSELL & CO., MOTHERWELL, N. B.

of small dimensions appear to be more ubiquitous than ever, and none are so popular as the horizontals. The early steam cranes all had vertical or inclined cylinders, which, in some small designs, involved tall framings. Later came the type with cylinders placed horizontally on the bed-plate, by which means the frames were kept low down,—a double advantage, because it lowered the centre of gravity, and left nothing to obstruct the view of the attendant when operating loads. By the diminution also of the weight and amount of work put into these cranes they come cheaper than the verticals, and are, therefore, favourites with contractors.

Though these cranes are not new, the later types show many improvements over their predecessors. The Taylor & Hubbard cranes, of which examples are given on page 322, embody the most

recent practice, the noticeable points being the use of wire rope for derricking the jib, instead of clumsy and more rigid chains, the neat parabolic outlines of the side frames, the protection of the gears that are most liable to injury, and the handiness of the levers. The trucks are either built up of plates and angles, with cast-iron centres, or of cast iron, and are fitted for common yard rails or for permanent way.

The portable steam cranes in their immense varieties possess great utilities. They are very tough, enduring much hard service and abuse in contractors' yards. Exposed to all weathers, they are fired hard, and knocked about over uneven ways, come into collision with

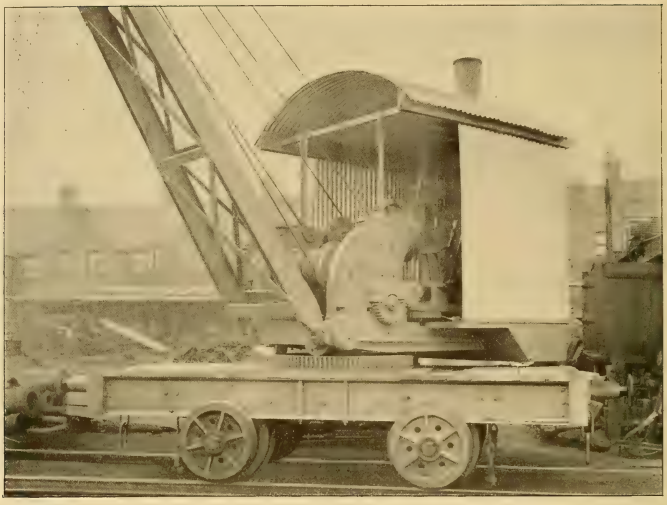
along. They are frequently made to derrick by means of worm gear on the derrick barrel, which, though slower, is safer than spur gears. Their trucks are not infrequently made to permanent way requirements. Sometimes two sets of wheels are fitted for two different gauges, one set inside and one outside the truck. Fitted with specially long jibs and wire rope for hoisting, they are the most handy cranes for unloading and loading barges and coasting vessels that are beneath the scope of the big transporters and coaling cranes.

A recent feature in these cranes is that the nuisance and hindrance involved in the use of blocking girders, or rail clips, is resulting in the growth of a class of

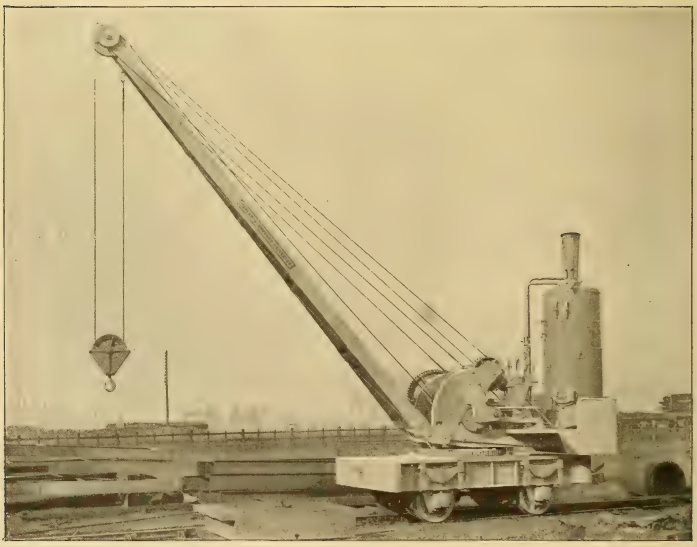
AN ARMSTRONG HYDRAULIC CRANE PICKING UP A COAL TRUCK AT THE LIVERPOOL DOCKS

various objects, with consequent injury to jib or trucks, while they are constantly doing the service of shunting locomotives in pushing loads of trucks

balance crane which has stability in all positions of the jib under maximum loads. It is a question of mass about the centre, of size of roller path, and dis-



A FIVE-TON CRANE WITH INNER AND OUTER SETS OF WHEELS FOR TWO DIFFERENT GAUGES. BUILT BY MESSRS. TAYLOR & HUBBARD, LEICESTER, ENGLAND

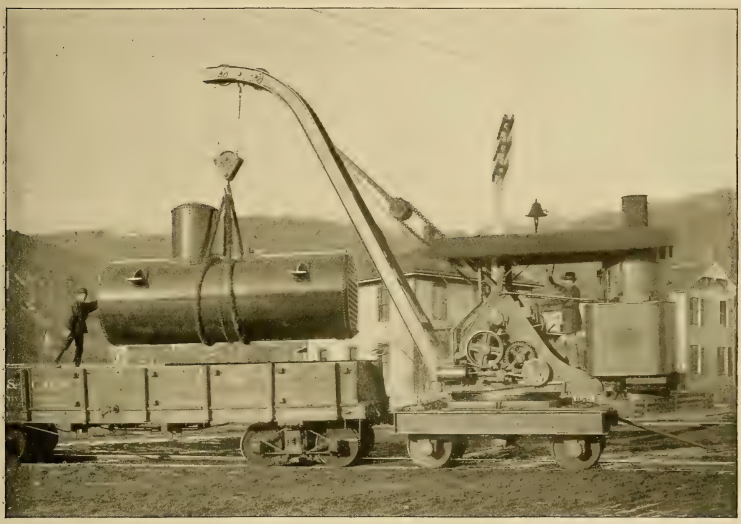


A FIVE-TON CRANE WITH TWO TRAVELLING SPEEDS FOR CLIMBING INCLINES. MADE BY MESSRS. TAYLOR & HUBBARD

position and weight of balance,—as the boiler and kentledge. A good example of a high-class crane of this type is seen in one of twenty tons capacity by the Brown Hoisting Machinery Company on page 330. Its maximum load is carried at 14 feet in any position of the jib while travelling. The eight running wheels are connected with equalisers, so that the crane will run round curves of only 100 feet radius. It travels at from

States. This is as marvellous in its way as the transporters and long-range cranes. For colliery and other work the electric winding engines and winches are used to a moderate extent, and the question of their increased employment is one mainly of cheapening the electric details.

The construction of harbours, breakwaters, and piers has been the occasion of the development of special lines of



A TEN-TON LOCOMOTIVE CRANE BUILT BY THE INDUSTRIAL WORKS, BAY CITY, MICHIGAN. U. S. A.

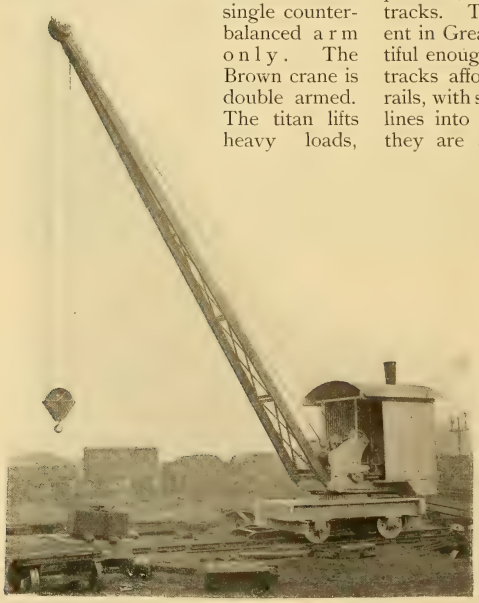
300 to 400 feet, lifts maximum loads at 25 feet, and light ones at 100 feet, revolves twice in a minute at full load and four times with light loads. The ten-ton hydraulic crane by Messrs. Fielding & Platt, shown on page 317, is also stable in all positions.

In the steam hoists the advances made have been remarkable. The common standard type of winch, with a single drum only, and one or two warping drums has grown into the double, treble, or quadruple-drum machines, and the machines with four, six, or eight spools are becoming common in the United

three types of cranes, the relative values of which are open to differences of opinion,—the titan, the goliath, and the derrick. The first is the creation absolutely of the demands of the monolithic construction of harbours, piers, and breakwaters; the second and third have been most highly developed in connection with this class of work. At Dover, on the Admiralty harbour construction, there are several immense goliaths of 100 feet span, capable of lifting sixty tons, but there is no titan. At other works one titan serves for the block-setting, and one goliath for the block-

making yard. The derrick has often been used for block-setting, but its chief value lies in the building of the temporary works on the sea front, that is, the staging on which the goliaths follow, and do the block-setting and diving-bell work.

Titan cranes are employed to an increasing extent. In view of the extensive growth of harbour work it is remarkable how little is known of these huge machines in the manufacture of which there is little rivalry. They are commonly made to lift blocks of 40 tons, but the largest will lift about 100 tons. Other cranes will hoist greater loads, but there are none that will lift them at so great a radius as the titans. The titans and the light Brown cantilever cranes have certain resemblances, but they offer stronger points of contrast. They both travel on tracks, of gauges sufficiently wide to afford stability under full loads. They both possess horizontal arms on which the trolley runs. But the titan has a single counterbalanced arm only. The Brown crane is double armed. The titan lifts heavy loads, travels, and traverses slowly; the other handles its light loads with extreme rapidity. Both have a most imposing appearance; but the one is a giant in strength, while the other makes up in speed what it lacks in power. It is not possible to say how long these contrasts will remain true. There is no apparent reason why the desirable features of the Brown crane should not be embodied in titans of high power. The automatic counterweight and the two cantilevers are so conducive to stability on a revolving crane that the diameter of the roller path can be safely lessened, while placing the engines or motors and all the gearing over the centre of the carriage gives dead weight, without adding useless material to obtain it.



A STEAM CRANE WITH A 40 FOOT JIB MADE BY MESSRS TAYLOR & HUBBARD, LEICESTER, ENGLAND

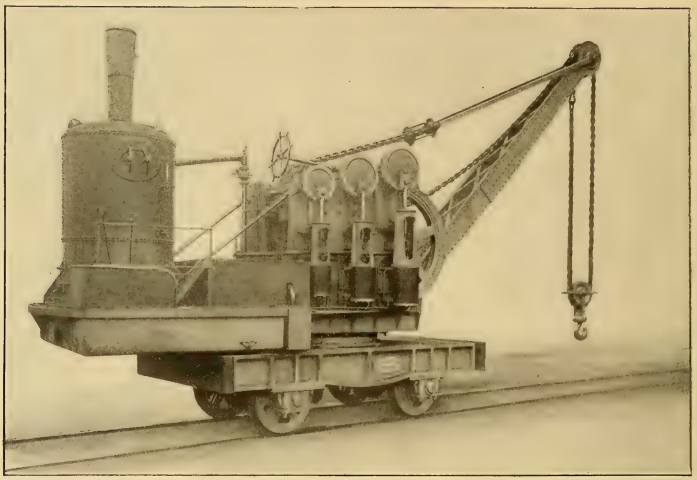
The most important developments in light cranes are found in the new types. In one class we have the substitution of compressed air as a motive power for other agents and the employment of portable, suspended hoists on overhead tracks. There are few of these at present in Great Britain, but they are plentiful enough in American shops. The tracks afford a perfect system of single rails, with switches for throwing meeting lines into or out of connection, and as they are arranged so will the hoists travel. The employment of these is effecting a thorough change of the old shop methods, and is becoming a strong factor in economic production.

Visitors to the recent Glasgow Exhibition could not fail to notice a peculiar crane that looked something like the combination of a telescope and crane jib. This was a "Garry" crane, operated by compressed air, the air cylinder being the portion that resembled a telescope. An advantage is that there is no gearing, the lift being direct, as in a suspended air hoist, the only essential difference being that the wire rope from which

A FIFTY TON FLOATING CRANE. WILL LIFT, SLING, AND SLEW 50 TONS AT 52 FEET RADIUS. BUILT BY MESSRS. HUNTER & ENGLISH, LONDON

the load is suspended passes over a pulley at the top of the jib, the jib and the cylinder being in line. The crane is mounted on a truck to run either on rails or on the ground, as required. Its base revolves on a live ring, and the cylinder and jib are pivoted on a pillar, thus rendering the movements of the jib universal.

One reason why cranes operated by electricity, water, and air have been developed and are extending so rapidly is, that power can be transmitted more conveniently by these agents than by steam. Even though the costs should come out about the same, the new agents are the handier. It is almost essential that steam cranes should carry their boilers and engines along with them. The square shaft for travellers is about as



A FIFTEEN-TON LOCOMOTIVE CRANE FOR HANDLING INGOTS IN STEEL WORKS, WITH A SEPARATE ENGINE FOR EACH MOTION. BUILT BY MESSRS. JOSEPH BOOTH & BROTHERS

clumsy, noisy, and wasteful a device as can be conceived. In fixed cranes the practice has often been adopted of bringing the steam to the cranes in pipes, and conducting it down through the crane post to the cylinders. Here condensation and loss of pressure is a serious drawback. Conveying power to fixed cranes by a line of shafting and changing the direction of motion at the crane with bevel gears is open to the same objection of wastefulness common to all shaft transmission, and this also is not favoured. Neither electricity, water, nor air are open to these objections except to a slight degree, and for that reason they have deservedly become favourite methods.

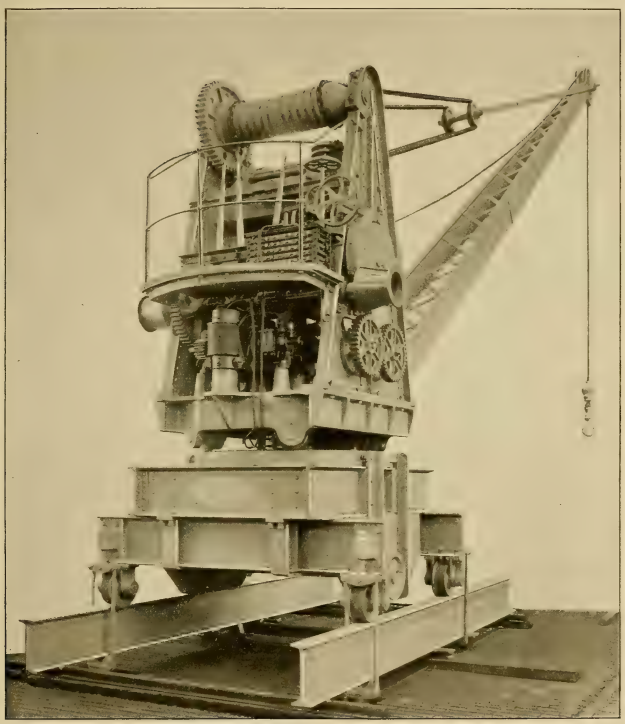
The economies of the modern crane are very great. One man can generally attend to the biggest of them, while two, four, or half a dozen men are required to handle the maximum loads of even the medium-power hand cranes. The difference in speed is another vast economy, and in the case of electrically-driven cranes the attendant is able to give his undivided attention to the levers and the instructions called out to him, instead of having to divide it between engines and stoking.

The demands made upon modern hoisting machinery have influenced the details of construction in various ways. Though higher speeds are demanded and deeper lifts, yet there is less risk of fracture of parts. Old materials have been largely discarded in favour of newer ones. Wire ropes are used in place of chains, steel-tired running wheels instead of those of cast iron. Mild steel is substituted for castings in the best trucks, and forgings for the posts, cast-steel wheels and gears are often used instead of those of cast iron, and phosphor bronze and Delta metal and rawhide gears for smaller high-speed pinions, while greater attention is paid to good gearing and kindred matters.

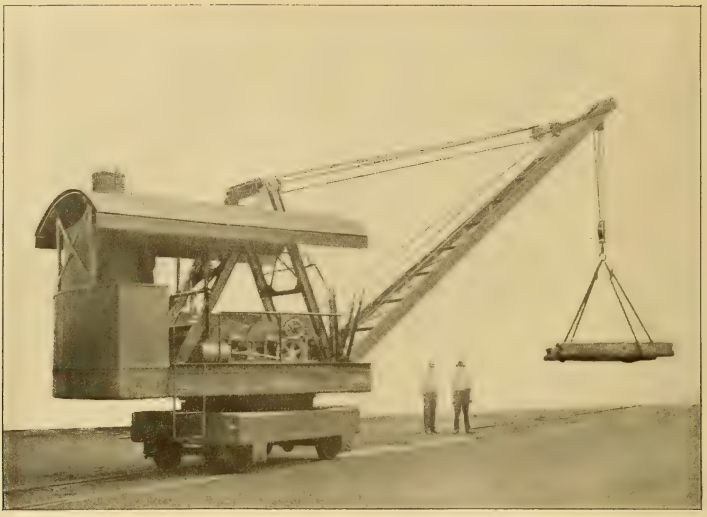
Wrought iron for plated framings of cranes and crabs, traveller girders, and for gantry framings was used for several years, but it is almost absolutely displaced by mild steel for plates, angles, tees, etc., and also now for rivets. In travelling and portable cranes of all kinds the lessening of dead weight, due to the reduced scantlings required in

steel, is a point of considerable value. In the larger cranes, gantries, and travellers the fact that plates and sections of larger area are obtainable in steel than in iron is a point in their favour, since the number of riveted joints is lessened. In the smithy wrought iron is stll used for parts that are subject to exceptional stress,—crane hooks, for example, shutting links, eye-bars, tie-rods, etc.,—but steel is used for ordinary parts. The importance of the smithy in a crane shop is great, and firms who are alive relegate much of this work to the die stamper, under the drop hammer, or the steam hammer.

The workmanship of cranes has been much improved in recent years. Almost anything used to be thought good enough for a crane by some people, as some believe still. And seeing how contractors knock about their plant, there is some reason in this belief. But the same rough class of workmanship used to be put more often into the better class of cranes than should have been the case. The writer has observed a great alteration in this respect. The precautions insisted on in high-class boiler work have had a reflex result in the plated work of cranes. Roughly shorn edges have given place to planed

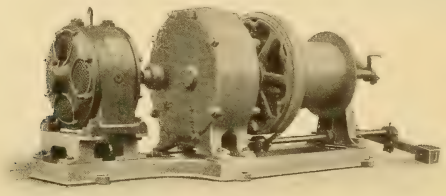


AN EIGHT-TON PORTABLE ELECTRIC CRANE. BUILT BY MESSRS JOSEPH BOOTH & BROS., RODLEY, NEAR LEEDS, ENGLAND



A LOCOMOTIVE CRANE, BUILT BY THE AMERICAN HOIST AND DERRICK COMPANY, ST. PAUL, MINN., U. S. A. MAXIMUM CAPACITY, 15 TONS AT 10 FEET RADIUS

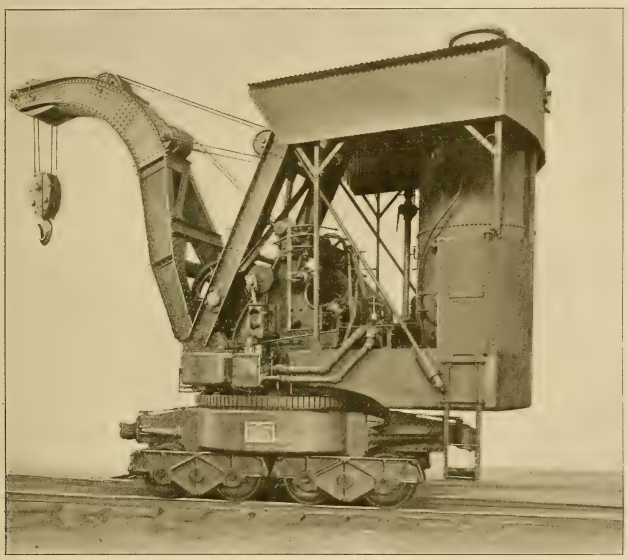
edges, and roughly punched holes to reamered holes. In important cast work, test bars are taken. Holes once left black are drilled, and turned bolts are inserted. Facings are planed; rapidly revolving parts are turned, even though not working fits; running wheels are turned on their treads. Cut teeth are employed in many cases where no crane maker would formerly have dreamed of putting them, but this is directly traceable to the introduction of the high-speeded gears of the electric traveller. Machine moulded wheels are used for the heavier gears in the best cranes, and for those which are half shrouded. Steel-tired running wheels are employed instead of cast wheels and chilled cast wheels. The barrels or hoisting drums are frequently cut; that is, the spiral groove for the rope is turned in the lathe instead of leaving it rough cast, with consequent detriment to the rope. More care is taken by some firms to attain some interchangeability in standard parts to facilitate renewals and repairs.



AN ELECTRIC HOIST MADE BY THE C. W. HUNT COMPANY, NEW YORK

The increasing importance of hoisting machinery is evidenced by the number of new firms that have taken it up, and by the growth of the industry in the United States, France, Germany, and Belgium. Many firms now make a specialty of some type or types of cranes; others manufacture anything that offers. But outside of these there are firms doing other and an entirely different

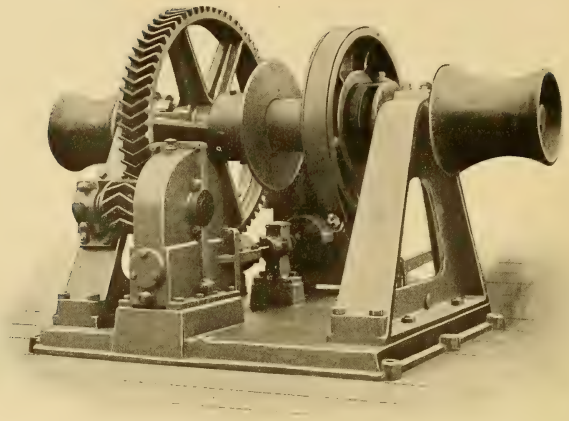
class of work who also undertake the construction of cranes of exceptional massiveness or for special purposes. There seem to be as many crane makers now in the United States and in Germany as in Great Britain, and though many of the German and French cranes have an *outré* appearance to us, and may certainly have weak points, that does not apply to all, perhaps not to the majority, and many are very excellent examples of this class of work.



A TWENTY TON LOCOMOTIVE CRANE BUILT BY THE BROWN HOISTING MACHINERY CO., CLEVELAND, OHIO, U. S. A.

The growing importance of some classes of hoisting machinery is scarcely grasped by the older crane makers or users. Nearly all the older types of hoisting machinery are certain to be affected by the advent of the new, in which everything is reduced to the most slender proportions consistent with the actual strength required,—steel sections, wire rope, and light trolleys taking the place of heavy castings, massive framings, rigid iron rods, and heavy crabs. The differences in dead loads and in speeds attained are great, and are wholly in favour of the new cranes. Add to this the fact that electric driving is adopted in these to a far greater extent than it is yet in the older, more solidly built types of cranes, and we have a set of conditions immensely in favour of the new. The differences are greater even than those between the modern electric traveller and the older square-shaft type, which it has so suddenly and almost completely displaced in new installations.

Great Britain was first in the field in the manufacture of hoisting machinery, and there it attained a high stage of development. When the Americans began to manufacture this class of machinery for themselves they started with no preconceived notions or prejudices, and American hoisting machinery is, therefore, different in many respects from British. Now under the circumstances just what might have been expected to



A FIVE-TON ELECTRIC WINCH MADE BY MESSRS. CLARK, CHAPMAN & CO., LTD., GATESHEAD-ON-TYNE, ENGLAND

occur,—knowing the American character,—has happened. Having a clean slate, they started to make machinery which should give the shortest cut to the results desired; hence the originality of many of their designs. And in machines which bear much resemblance to those made in Great Britain they have gone on more or less original lines in the working out of details.

STANDARDISATION IN THE BRITISH ENGINEERING INDUSTRIES

By a London Correspondent

IN considering the question of the cost of production and how British industry may best meet the requirements of an ever-extending empire and foreign competition both at home and abroad, we are forced to recognise that in many of our methods there is not only a lamentable want of system, but also a widely felt need of some authoritative and acknowledged set of standards.

The want of system which prevails in many branches of British engineering industry has arisen from causes which are not always apparent, and consequently the fault is sometimes laid upon the shoulders of those who are not really entirely responsible for it. It is the outcome of a gradual development extending over many years. British engineers have not had the advantages of younger countries of being able to design with a clean sheet before them, untrammelled by existing plant and long established customs. They have usually had to adapt their designs to existing work, and this has often precluded them from doing their best, or what they would have done had they had a freer hand.

Take, as an example, the chaos that

at present exists in the multitude of rolled sections used in Great Britain and in her colonies and dependencies! Many of the odd sections now in use have arisen from the fact that John Smith twenty years ago made, say, a bridge or some other structure for, perhaps, one of the colonies. With the view of ensuring that any repeat orders should come back to him, he incorporated in his bridge some odd sections made or used only by himself. This practice was frequently resorted to in the early days before screw threads were standardised, when, if a machine broke down, you had to go to the maker of the machine to replace the nuts and bolts. Whitworth then appeared on the scene, and in face of much opposition created order out of chaos.

But to return to our example:—John Smith's bridge was duly sent out, abroad, and erected, and as the material employed by him was first-class stuff, nothing more was heard of it for some years. In the meantime, John Smith's firm becomes extinct, or changes hands. Something happens to necessitate either extension or repairs to the bridge, and the engineer on the spot sends an indent home for several tons of John Smith's own peculiar section. The consulting engineer acting on behalf of the colony in Great Britain sends round to the firms usually supplying him with rolled sections for a few tons of this odd section, which perhaps differs from the sections at present in current use only by some fractional part of an inch. Naturally, the makers ask why on earth consulting engineers specify such odd sections, being ignorant of the fact that it was originally John Smith, one of their own number, who was entirely responsible for the section in question.

To cite another instance of the way idiosyncrasies of this kind propagate themselves,—a maker is asked to cut a special section, and as the order in the first instance may amount to several hundreds, if not thousands, of tons, he has no hesitation in spending two or three hundred pounds in providing new rolls to secure the order. As he has the rolls for this special section, the latter naturally finds its way into the next edition of his section book. This book is freely circulated, and in due course finds its way into an engineer's office, where, say, a bridge is being designed. The draughtsman in charge, seeing the section published in the maker's book, not unnaturally presumes, with a fair amount of reason, that if the maker has the section in his book, that section is a marketable article, and can safely be incorporated in the design of the bridge without further question. The contract for the bridge is let, and when the contractor comes to look carefully into the sections to be used he finds this odd section.

Perhaps, to make matters worse, only a comparatively small quantity is required, and the maker has none of this special section in stock, and has very little likelihood of obtaining sufficient orders for it to warrant him putting in the rolls required for it. He may, however, go so far as to accept the order, trusting that he may obtain, before long, sufficient orders for this odd section to warrant him in rolling it. Unluckily for the contractor, the rolling mill maker's expectations are not realised; the contractor has to wait for months for this odd section, and all concerned in the contract, whether as purchaser, contractor, or consulting engineer, are put to great inconvenience, not to speak of expense, on account of the delay.

British industry is constantly being handicapped by this want of system, especially in cases where price and delivery are prime factors in the placing of an order. It enables countries like America and Germany, where the standardisation of rolled sections has already been accomplished, to successfully compete with Great Britain.

Standardisation should never be attempted in any branch of industry until a certain amount of diversity exists. Sufficient time must have been allowed for the process of natural selection to have determined what is best suited to the requirements of any particular industry.

Standardisation of too drastic a nature is not without its drawbacks. If car-

ried to excess it may, no doubt, have a tendency to stereotype design, but the advantages accruing from wisely directed standardisation are real and far reaching. Real genius shows itself, not in the multiplication of petty details, but in the assimilation of existing materials and their incorporation into a broad and comprehensive design. An engineer shows his ability by utilising what materials he finds ready to hand, rather than by the creation of special forms a little different from what has been used before. No doubt there are cases in which special needs have to be met by special designs and nothing exists in current practice which the engineer can utilise to give the best solution of the problem that he has before him, but such cases are comparatively rare.

It is evident that standardisation must not hamper or restrict the future development of any industry. On the contrary, it must move with the requirements of the times, or it will prove a hindrance to progress rather than a help. The aim of those engaged in standardisation must be to encourage and direct progress along the best and most efficient lines, by incorporating as standards only what, from a practical and scientific point of view, they consider best suited to meet the requirements of the industry.

To cite a practical instance, supposing the maximum depth of joists at present rolled to be 20 inches, it would be desirable to standardise a little ahead of the existing sections and include, say, a 24-inch girder amongst the standards, so as to preclude the adoption of such an irregular section as a 23½-inch joist. The interest of the individual must, in the long run, give way to the interests of the majority.

There is one important point that must be clearly borne in mind, and that is that the selection of a certain number of standards does not entail the exclusion of anything which is not contained in those standards. Care must be taken to distinguish between a general set of standards which will meet the requirements of the vast majority of cases encountered in everyday practice and special designs, required to meet the exigencies of any particular case. If the circumstances warrant the engineer in putting forward a special design differing, it may be only slightly, from the acknowledged standard, then the circumstances justifying the special design will also justify the extra cost that the departure from the acknowledged standards will entail. The advantage of a set of standards is, that as an engineer would have to justify his departure from them, it would prevent the introduction of needless odd sections.

Sir John Wolfe Barry, when addressing the Goldsmiths' Institute, aptly put it thus,—"Standardisation and simplification mean cheapness and rapidlty in supply; complication and a chaos of unnecessary shapes and sizes mean dearness and delay."

Under no circumstances must a series of standards be looked upon as final, and means must be provided for adding to the standards as the requirements of any industry indicate such additions to be desirable. The possession of an acknowledged set of standard sections will be invaluable to British colonial and Indian engineers. When ordering from Great Britain they will know that they will be able to procure standard sections with the least possible delay and at a more or less fixed price. No doubt in due time merchants will find it worth their while to stock at least a certain number of the standard sections, and an engineer may be able to obtain delivery in the colony itself, or if neighbouring railways are both using standard sections, in case of a breakdown or some other emergency one engineer may be able to draw upon the stock of his brother engineer. This is often made impossible at present by the use on two adjoining lines of, say, tires and rails which, though very close to one another, are just sufficiently different to prevent one engineer from helping his neighbour in a case of need.

The question of standardisation involves the important and difficult question of the units in which the standards are to be expressed. The linear dimensions must either be stated in feet and inches and their sub-divisions, or in the

metric system. There are at present in use in Great Britain, in connection with rolled sections, the following methods of measurement:—

1.—The inch, with its divisions into eighths, sixteenths, thirty-seconds, and sixty-fourths, in general use throughout Great Britain and her colonies and dependencies, and also in America.

2.—The inch sub-divided into tenths, used by some of the makers in their section books, but chiefly for scientific purposes.

3.—The inch sub-divided into twentieths, used by Lloyds' Corporation, the most powerful registry society in the shipbuilding world.

4.—The inch sub-divided into fortieths, used by the British Corporation for the Registry of Shipping.

5.—The weight per foot run, which is the system of measurement adopted by the British Admiralty.

That such a multiplicity of systems in stating the thicknesses of rolled sections should exist in one country is, perhaps, not realised by the general engineering world, and the need of some acknowledged standard method of measurement is made apparent by it. What that method is to be has yet to be determined, but it is clear that if unity is to be secured, minor differences will have to give way to the greater good of the whole community. This refers only to British insular differences, and does not touch the greater question as to whether the linear dimensions of the various rolled sections should be stated in millimeters.

The questions involved and the interests affected by the adoption of any given system of measurement are more far-reaching than may appear at first sight. British interests are not confined to the United Kingdom, but extend to all quarters of the globe. The railways of Britain's colonies and dependencies are largely guided and controlled from the home country either by the government departments or by their own boards of directors and consulting engineers. Nearly all the work executed by Great Britain has been carried out with the foot and its various sub-divisions as a basis of measurement. Either the present system of measurement has to be maintained, if the standards are to fit work at present in existence, or the metric system is to be adopted, in which case the standards on that system would not fit the vast amount of the work which has been carried out with the foot as the basis of measurement.

In an article that appeared in the London *Times* last November, referring to the appointment by the Institution of Civil Engineers, in conjunction with the Institution of Mechanical Engineers, the Institution of Naval Architects, and the Iron and Steel Institute, of a very influential committee who are at present enquiring into the question of standardisation, it was suggested that the efforts of the committee should be directed, if possible, "to adopt the metric system of measurement in the standards which they recommend." No doubt the adoption of the metric system by Great Britain for its standards would be hailed with delight by all those countries which are now using that system. It would still further throw open British markets to foreign competition, and as the cost of production abroad is, generally speaking, lower than the British, it would, no doubt, result in foreign makers securing many contracts which they are now unable to obtain on account of the difference in the system of measurements in use in the different countries.

The Germans have already a splendid set of standard sections which they have carried through with their usual thoroughness, and which have been largely adopted by other countries employing the metric system; if, therefore, British manufacturers wish to enter into competition with their foreign confrères they already have means of doing so in their own hands. From what we know, however, of British competition in foreign countries, it is far more likely that the foreign makers will cut a set of British standard rolls directly the British standard sections are issued, rather than that any British firm will cut, or have cut, a set of standard foreign metric rolls. If, therefore, the British rolling mill owner wishes to carry the war into the enemy's camp, he has only to cut a set of stand-

ard metric rolls; but it is to be feared that, with the low prices at present obtaining abroad, this would not be a very lucrative undertaking. It is extremely unfortunate that there is nothing which could serve as a connecting link between the metric and the British units.

A standard, to be worth anything at all, must be absolutely accurate, and, further, a set of standards must be stated in even dimensions. The Germans go up by five or ten millimeters, according to the size of the section. A British set of standards would have to proceed by inches or half inches. What is an even dimension for the British system would be an odd dimension in the metric system, and what is even in the metric system would be odd in the British. Take, for instance, an 8-inch girder! The nearest even metric size to 8 inches is 200 mm., or practically 7⅞ inches. Eight inches are nearly 203 millimeters. Now, though in many cases the odd three millimeters in height might make very little difference in practice, yet whichever set of units is decided upon, the standards in one system must necessarily be an odd size in the other.

There can be no question that, from a theoretical point of view and for facilities in calculation, the metric system has advantages, and no one who has ever been used to making calculations in the one system would willingly return to the "barbarous" British units, with their sixteenths, thirty-seconds, and sixty-fourths, if it could possibly be avoided. The difficulties surrounding this question and the proposition suggested in the *Times* article above referred to, hinge, not so much on the theoretical side of the question as on the large orders coming daily to Great Britain from all parts of the British Empire for material to be used in conjunction with existing material and which has been made to British units. It is significant that America, which has had a far freer hand in these matters than Great Britain, being a younger country, has issued what standards she has in British and not in Continental units.

So far, nothing has been said of a very important side of the question, namely, the financial one. If the introduction of the metric system were warranted by other considerations, the financial aspect would not stand in the way. Rolls will not last forever, and as old rolls had to be renewed, others on the metric system could easily be cut to take their places. But, as the writer of the *Times* article says, "old rolls would have to be retained in order to meet any orders for the renewal of parts in designs which had been carried out previous to the change," and this would make it necessary for British manufacturers to keep on hand for a considerable length of time two complete sets of rolls. The fact that Continental standard sections have existed for some time, and that neither in Great Britain nor in America it is usual to keep a set of standard metric rolls, would seem to indicate that, after all, the foreigner has more to gain than Great Britain by the adoption there of the metric system for standard sections.

There is another direction in which the want of standardisation is being most acutely felt, and that is in the matter of tests. Much valuable work has already been done in certain industries, notably by Lloyds in the shipping industry, but in the majority of cases it has been left to consulting engineers to specify their own particular tests, and the result has been that contractors have been obliged to comply with the requirements of several different specifications for what, to all intents and purposes, is the same material, and is to be used for precisely the same purposes. The differences in these specifications often consist only of minor details, and do not involve any important departure in the nature of the material.

It must be admitted that steel and the other more generally used materials are now sufficiently well defined and determined in their composition to enable a series of standard tests and specifications to be issued, to which the vast majority of engineers and manufacturers would gladly adhere. This would enable a manufacturer to turn out larger quantities of any given material at a cheaper rate and with the certainty that, sooner

or later, if it was made and tested according to the standard specifications, he would have no difficulty in finding a ready market for his commodity. It would also obviate the difficulty, which is at present not unknown, of a chemical test result being specified, which, taken in conjunction with the mechanical tests required, is wellnigh impossible of attainment.

Cases must of necessity arise in which departures would have to be made in standard specifications. These cases could easily be met by the consulting engineer, whose work necessitated special requirements, paying a slightly higher price to secure his particular material. One of the difficulties arising from the multiplication of tests required is that where a firm is turning out, say, plates to pass the Board of Trade, as well as plates to pass Lloyds and the British Admiralty, the tests specified by these three bodies are not identical, and if the inspector for one of the bodies happens not to be at the works the work on his plates cannot be proceeded with, as one inspector cannot accept material for the other. It would be of immense advantage if some agreement in this direction could be arrived at, and considering the smallness of the differences that exist between the various tests specified by the three bodies above referred to, there seems to be no insuperable difficulty, at least from a technical point, of arriving at a mutual understanding.

Much has been said of late in the newspapers concerning the standardisation of locomotives, but as the Committee of Indian Locomotive Superintendents and others are at present engaged on this subject in India, it is not advisable now to deal with it further in other places. Whatever may be the results arrived at as to the standardisation of locomotives and their leading dimensions, one point is beyond dispute, namely, that there is room for a vast amount of improvement in the unification of the various specifications to which the materials used in locomotive construction are subjected.

The president of the Institution of Civil Engineers, Mr. Charles Hawkesley, in a recent address to that body, dealt with this subject in a clear and comprehensive manner, and the action of the committee appointed by the four institutions named above will be watched with extreme interest by the entire engineering world. The names of the men forming the main and sub-committees afford every guarantee that the best engineering skill of Great Britain is at their disposal, and that the interests of the trade of the country could not be in better hands.

In concluding these remarks, we may echo the keynote so wisely sounded by Mr. Charles Hawkesley in his address, when he said that "engineering designs must not be reduced to the level of the manufacturers' standards, but rather that the standards must be kept abreast of the requirements of the engineer."

AN AMERICAN INDUSTRIAL PEACE CONFERENCE

By the Hon. Oscar S. Straus, President of the Conference

THERE assembled in the rooms of the New York Board of Trade and Transportation on December 16 and 17, 1901, a conference which, I believe, will take a marked place in the world's history. It included some of the most important and largest-minded of the great employers of labour, and it brought together some of the foremost and strongest leaders of the national labour organisations. With them also sat some of the most revered and wisest leaders of thought, who represented the general public.

The group was not large, but the men represented immense interests, and they were earnest and determined. They had assembled to see if it were not possible to establish some practical plan for the lessening, if not the prevention, of industrial disturbances. They met in the belief that if the representatives of employers and workmen could get fairly together, as man to man, on an equitable, candid, conciliatory ground, both might discover that there was no reason for conflict, that there was a mutuality of interest, that the objects of each might be attained by sensible and friendly methods, and that strikes and lockouts might be avoided.

This conference and the movement it organised were the crystallisation of a plan which many earnest and sagacious men have hoped for and had under consideration for years. After all the panaceas of the reformers were calmly reviewed, there had been growing up a general feeling that there must be some very simple and direct way by which sensible men could compose their differences and live together in industrial peace, giving to natural forces a free chance to work out their beneficent results. The plan of mutual agreements, the reciprocal recognition of the necessity for organised capital and organised labour, the spirit of friendly conciliation,—these ideas have, I think, been gathering force among practical men for a long time.

Half a dozen years ago Mr. Ralph M. Easley, of Chicago, formerly a Kansas editor, came to the conclusion that what was most needed was a friendly comparing of diverse views by the most intelligent and most representative men, and a consequent arriving at some common ground. The result was the starting of the Chicago Civic Federation, which presently expanded into the National Civic Federation, and busied itself in various departments of political, commercial, and industrial progress. It was this Federation that in 1898, just before the treaty of peace, called together the Saratoga conference on the future foreign policy of the United States. The

REPRESENTING THE PUBLIC
THE INDUSTRIAL DEPARTMENT OF THE NATIONAL CIVIC FEDERATION

REPRESENTING EMPLOYERS
THE INDUSTRIAL DEPARTMENT OF THE NATIONAL CIVIC FEDERATION

next year it conducted the conference in Chicago on the general question of "trusts." Again, in 1901 it summoned the conference in Buffalo to consider more equitable systems of State taxation. All of these conferences were addressed by some of the best-known men, and were influential in clearing the air and presenting the main issues squarely to the public.

But it was in the industrial department that the most conspicuous and beneficial results of the Federation were to be achieved. An industrial conference met in Chicago in December, 1900. After an able discussion of the methods of mutual agreement and conciliation to prevent strikes, a committee of six leading employers and six prominent labour leaders was appointed to further the purposes in view. The conference also published a modest appeal to the public in which there were some significant statements. This is one of them:—

"We duly recognise that unless labour is regularly employed and has reason to be satisfied with its wages and conditions in life, we cannot have permanent peace nor substantial prosperity. We also recognise that capital must find adequate returns for its investment if wages are to be fair and discontent is to be averted."

It recommended that employers and wage-earners should enter into annual or semi-annual contracts; that all industries should appoint their own boards of conciliation; that the twofold permanent committee of the conference try to inaugurate a general system of conciliation; and urged the maxim that the true time to arbitrate is always previous to a strike.

This meeting and this appeal had attracted enough attention, so that when the next conference was called, at New York, in May, 1901, it was attended with a general interest on the part of the press and the thoughtful public. Public meetings were held, and addresses were made by men of commanding importance. The principles of the "appeal" of the Chicago conference were reaffirmed, and the appointment of a larger executive committee was authorised to carry them into effect.

But before this permanent committee could be appointed the friends of the movement had their hands full in the practical business of settling some large disturbances. For on the heels of this conference came the serious Albany street-car strike; indeed, before the adjournment a message was sent to the officers that the street cars in Albany were tied up, and if there was any value in the doctrine of conciliation, this was a case to which it should be applied. The hint was taken, and a committee, consisting of John Mitchell, Herman Justi, Daniel J. Keefe, and R. M. Easley, was appointed to do what they could to settle things. When Secretary Easley arrived at Albany the military were in possession of the streets. But through the discreet offices of the committee an agreement was drawn up which formed the basis of the final settlement.

Later came the unhappy, prolonged steel strike. A committee of the Civic Federation, among whom were Messrs. Gompers, Sargent, Mitchell, Jenks, White, and Easley, took an active part in seeking to bring it to an end. They urged upon President Shaffer, of the Amalgamated Association of Iron and Steel Workers, the advisability of accepting the Morgan-Schwab offers. When these offers were refused, the committee stood like a rock in preventing the general sympathetic strike by which it was planned to tie up railroads and coal mines. It is to be noted as a fact of interest that the personnel of this committee which thus urged the determined strikers to accept fair offers and prevented the vast sympathetic strike of many industries was chiefly composed of labour leaders; it was their firmness and foresight that saved the country an incalculable loss. This instance is significant in suggesting the spirit of conservatism that is now dominant among the responsible leaders of labour.

There had been no public blare about these judicious and earnest efforts of the active promoters of conciliation in the name of the Civic Federation, but

REPRESENTING WAGE EARNERS
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the proof of their work was well known in those quarters where it had most influence. Consequently, when the call for the New York conference of December 16 and 17, 1901, was made, there was an immediate and hearty response by that class of men whose names carry national weight. A meeting to abolish industrial violence and to inaugurate friendly methods of adjustment, which gathered such men as Senator Hanna, one was in the spirit of amicability, concession, and resolute hope.

Bishop Potter said:—"The misery of modern industrial life has been in its isolations. The moment you get great bodies of men who know nothing about each other you have got the germs of evils. To re-establish the contact of isolated industrial bodies is the greatest service that can be rendered."

Senator Hanna had avowed that he

THE INDUSTRIAL DEPARTMENT OF THE NATIONAL CIVIC FEDERATION

On the part of the Public

GROVER CLEVELAND, Ex-President of the United States, Princeton, N. J.
CORNELIUS N. BLISS, Ex-Secretary of the Interior, New York City.
OSCAR S. STRAUS, Ex-Minister to Turkey, New York City.
CHARLES FRANCIS ADAMS, former President of the Union Pacific Railroad, Boston.
ARCHBISHOP JOHN IRELAND, of the Roman Catholic Church, St. Paul.
BISHOP HENRY C. POTTER, of the Protestant Episcopal Church, New York City.
CHARLES W. ELIOT, President of Harvard University, Cambridge, Mass.
FRANKLIN MACVEAGH, Merchant, Chicago.
JAMES H. ECKELS, former Comptroller of Currency of the United States, Chicago.
JOHN J. McCOOK, Lawyer, New York City.
JOHN G. MILBURN, Lawyer, Buffalo.
CHARLES J. BONAPARTE, Lawyer, Baltimore.
RALPH M. EASLEY, Ex-officio, Secretary of the National Civic Federation, New York City.

On the part of Employers

MARCUS A. HANNA, Coal Mines, Iron, Shipping and Street Railways, Cleveland.
CHARLES M. SCHWAB, President of the U. S. Steel Corporation, New York City.
S. R. CALLAWAY, President of the American Locomotive Company, New York City.
CHARLES A. MOORE, President of The Shaw Electric Crane Company, New York City.
JOHN D. ROCKEFELLER, Jr., New York City,
EDWARD P. RIPLEY, President of the Atchison, Topeka & Santa Fe Railway System, Chicago.
J. KRUTTSCHNITT, Vice-President of the Southern Pacific Railroad Company, San Francisco.
H. H. VREELAND, President of the National Street Railway Association, New York City.
LEWIS NIXON, Proprietor of the Crescent Shipyard, New York City.
MARCUS M. MARKS, President of the National Association of Clothing Manufacturers, New York City.
JAMES A. CHAMBERS, President of the American Window Glass Company, Pittsburgh.
WILLIAM H. PFAHLER, Ex-President of the National Founders' Association, Philadelphia.

On the part of Wage Earners

SAMUEL GOMPERS, President of the American Federation of Labour, Washington.
JOHN MITCHELL, President of the United Mine Workers of America, Indianapolis.
FRANK P. SARGENT, Grand Master of the Brotherhood of Locomotive Firemen, Peoria, Ill.
THEODORE J. SHAFFER, President of the Amalgamated Association of Iron, Steel and Tin Workers, Pittsburgh.
JAMES DUNCAN, General Secretary of the Granite Cutters' National Union, Boston.
DANIEL J. KEEFE, President of the International Longshoremen's Association, Detroit.
JAMES O'CONNELL, President of the International Association of Machinists, Washington.
MARTIN FOX, President of the Iron Moulders' Union of North America, Cincinnati.
JAMES M. LYNCH, President of the International Typographical Union, Indianapolis.
EDGAR E. CLARK, Grand Chief Conductor of the Order of Railway Conductors of America, Cedar Rapids, Iowa.
HENRY WHITE, General Secretary of the United Garment Workers of America, New York.
W. MACARTHUR, Editor of the Coast Seamen's Journal, San Francisco.

Samuel Gompers, Charles M. Schwab, John Mitchell, Archbishop Ireland, Bishop Potter, Cornelius N. Bliss, S. R. Callaway, Frank P. Sargent, Daniel J. Keefe, Lewis Nixon, Charles A. Moore, John J. McCook, and Henry White was in itself significant of result.

The addresses were, without exception, appreciative of the momentous significance of the occasion, and each would rather have the credit of making successful the movement to bring capital and labour together than to be President of the United States, and he now declared:—

"It is my all-absorbing interest and firm determination to join with all those, both labourers and employers, who will strive to bring about a condition of things which will accomplish more in

the direction of good government, good social relations, and good morals than any one question which the public mind can take hold of. I stand ready, and willing, and anxious while life remains to give the best that is in me to accomplish this purpose."

Lewis Nixon said:—"We have got to recognise the union man, for he is here to stay, and is growing stronger all the time. The corporations are growing stronger, too, and we cannot afford a battle of giants. They must get together and effect a mutually satisfactory compromise. I believe we are going to bring about an industrial clearing house here, to which all industrial disturbances will be referred for settlement."

John Mitchell, who said he had been in more strikes than any other man of his age, declared:—"I have never seen in my experience a strike that could not have been avoided if the employers and the men had met in conference before the strike was started."

Samuel Gompers asserted that he "had never joined in the hue and cry against those combinations of capital commonly known as trusts," and he believed that the result of this conference was to be "a distinct stride in advance toward an understanding between capital and labour. Both sides have met in harmony and have agreed upon a plan that seems destined to bring the best results."

Archbishop Ireland's closing words, as the conference ended, were:—"Let us have industrial peace; let employer and employee know that they are brothers."

These sentiments were representative of many others, as cordial and as illumined, which were expressed by other gentlemen. Before the adjournment Mr. Frank P. Sargent, Grand Master of the Brotherhood of Locomotive Firemen, moved the appointment by the chair of an executive committee of thirty-six, to be composed equally of men standing for employers, labour organisations, and the general public, who should have authority to inaugurate the practical workings of the method of conciliation in such ways as seemed wisest.

The next day this tripartite committee was announced, and as many of its members as were in New York met and agreed upon a statement of the plan and scope of its proper work. This permanent executive committee is made up as shown on page 341.

Its officers, who were immediately elected, are:—

Marcus A. Hanna, *chairman;* Samuel Gompers, *first vice-chairman;* Oscar S. Straus, *second vice-chairman;* Charles A. Moore, *treasurer;* Ralph M. Easley, *secretary.*

The first result of the deliberations of this committee was the adoption of a statement of the Plan and Scope of its work as it conceives them to be. This carefully expressed paper is as follows:—

"This committee shall be known as the Industrial Department of the National Civic Federation.

"The scope and province of this department shall be to do what may seem best to promote industrial peace; to be helpful in establishing rightful relations between employers and workers; by its good offices to endeavour to obviate and prevent strikes and lockouts; to aid in renewing industrial relations where a rupture has occurred.

"That at all times representatives of employers and workers, organized or unorganized, should confer for the adjustment of differences or disputes before an acute stage is reached and thus avoid or minimise the number of strikes or lockouts.

"That mutual agreements as to conditions under which labour shall be performed should be encouraged, and that when agreements are made the terms thereof should be faithfully adhered to both in letter and spirit by both parties.

"This department, either as a whole or a subcommittee by it appointed, shall, when requested, act as a forum to adjust and decide upon questions at issue between workers and their employers, provided in its opinion the subject is one of sufficient importance.

"This department will not consider abstract industrial problems.

"This department assumes no powers of arbitration unless such powers be conferred by both parties to a dispute.

"This department shall adopt a set of by-laws for its government."

This is the narrative up to the present hour of a movement which I cannot but consider to be highly important and whose eventual influence in the reconciling of capital and labour can scarcely be overestimated.

My reasons for this belief are plain ones. The composition of the executive committee is of itself a guarantee of breadth of view and determination of purpose. In the first place, it stands for the three great interests involved, capital, labour, and the general public. It is observable that the men who have been chosen from the two sides of capital and labour represent interests and organisations so wide-reaching that it is hardly possible for any industrial dis-

turbance of great extent to arise which is not directly touched by some of the men on this committee. When such a disturbance arises, which will summon this committee together, the very assembling of it will inevitably be a potent force. For the main thing always, as Mr. John Mitchell said, is the getting together, face to face, of those who are most interested.

Both sides recognise, nowadays, that there are a thousand reasons for averting a resort to the ordeal of the strike; and when the interested parties get together on common ground the first thing is a removal of misunderstandings and the candid consideration of the position of both. They come together, not to fight, but to see if a fight may not be avoided; and if the fight has begun, they come together to see how to stop it. Wherever the moral pressure needs to be brought to bear the party that is asked to concede cannot, under the present complex conditions, refuse to do so without arraying against itself the solid force of public opinion.

Two illustrations from the year 1901 exemplify this truth. When, in February, there was threatened a general strike of the 150,000 anthracite coal miners in the United States, it was Mr. J. Pierpont Morgan who throttled it by urging that their chief demands be met by the operators. The coal trouble began, it will be remembered, in the dangerous strike of the summer of 1900, which Mr. Hanna was a factor in settling by securing a six months' agreement as to a scale of wages. When that period was about to expire, the miners instructed Mr. John Mitchell to demand a renewal of the agreement and a recognition of the unions, or to call a general strike. It was the energy and instant action of Mr. Easley, of the Civic Federation, that, with no small difficulty, brought together Mr. Mitchell and Mr. Morgan. The result was a granting of the wage scale, and a compromise on the recognition of the unions. The other instance is that already referred to wherein such labour leaders as Messrs. Gompers, Mitchell, Sargent, and White urged upon the Amalgamated Steel Workers the acceptance of the Morgan-Schwab offers.

Another feature of marked strength in this tripartite committee is that element of it which stands for the general public. This third or public side is present with open mind to consider, without fear, favour, or prejudice, the questions that arise between capital and labour. The characters of these men are such that their judgment will command respect on both the contending sides. They will be the true interpreters of that sense of justice which is at the basis of enlightened public opinion.

Another reason for my belief in the far-reaching effect of this movement is in its wise, and temperate, and altogether workable platform. A careful reading of that precisely phrased instrument makes several facts apparent. In the first place, this committee does not constitute itself a Board of Arbitration, save in cases when both sides to a controversy may request its service. Again, it recognises all labour, organised and unorganised. Once more, it is not to be an academic arena to discuss social panaceas or abstract theories affecting capital and labour; but the Plan and Scope are emphatically framed to reach practical ends. The committee has, as such, no opinions to express regarding theoretical propositions. On the other hand, it reserves to itself the right to take such action as may seem best when the concrete proposition arises.

In view of these expressed purposes the line of the work of the committee seems plain. It is true, this is a matter of opinion, and I wish here, as throughout this article, to be understood as expressing only my individual opinion, and not as speaking for the committee of which I am but one member. In my opinion, the chief result of the committee's effort will not be in battles won, but in battles prevented. And whenever a battle begins, in spite of the committee's endeavour, its next work will be to bring such a battle to as speedy a termination as possible.

This is, doubtless, considerably less than many men have fancied the movement had booked for itself. The public,

however, should not be misled in expecting too much from the work of the committee, and for that reason I have incorporated the Plan and Scope, which, I trust, may be read with discriminating care.

INDUSTRY AND ELECTRICITY IN GREAT BRITAIN

By W. E. Langdon, President of the Institution of Electrical Engineers

THERE can be no question that there exists in commercial circles at the present time a large degree of unrest in respect of industrial production. That there is cause for this we have sufficient evidence in the fact that foreign houses are competing, and often with success, with British manufacturers for the material wherewith to carry out British work. Lord Rosebery and Mr. Joseph Chamberlain have, equally forcibly, commented upon England's position, urging education and travel.

The advantages of education and travel no one will deny. Science and technical education have not only made known the mode of manufacture, but have shown us the reason for that mode. That which was known to the few has become the knowledge of all who care to ask for it. Combined with this we have to face those large trusts and combinations supported by wealthy capitalists, calling to their aid all the most improved means for effecting economy in both labour and material. Another and mporta nt feature to be noticed is that contemporary with that spirit of enterprise and competition which marks the period is the advent of electricity as an agent for the distribution of power. Herein lies mainly the cause of that unrest. Education, technical instruction, and the means to apply it to the greatest advantage! For all this the world is the richer, but it brings with it a desire to turn it to advantage,—to participate in gaining that which the world covets,—wealth. Hence, competition. In this competition electrical energy is destined to play an important part.

The first great impetus imparted to industrial production was derived from steam. Prior to the advent of the steam-engine, Nature's resources,—wind and water,—were the only sources which mechanical manufacture could call to its aid. Steam as a motive power, however, has its limits. It is economical only within a certain area. Beyond that area it is necessary to lay down additional plant. Thus, in large works many steam units have to be employed. With the advent of the dynamo we were enriched by a means for distributing power with far more simplicity, and greater certainty and exactitude. Compare, for instance, the convenience and facility in operation of an electric motor with a steam installation, consisting of boiler and engine! Consider the saving in space and capital expenditure! Make the same comparison with a gas-engine, and still how great is the advantage of the electrical agency! Regard, again, the advantage and economy attending the application of these electric motors direct to the shafting, or the machines usually driven by belting, or belting and shafting! All this is now being recognised by advanced firms, and numerous instances might be quoted where distributed steam units have been replaced by electric motors driven from a central source of power.

These advantages are mainly, so far, local,—confined to those large works which have the capital to invest in the new power. Springing into existence all over the country, however, are undertakings for the provision and distribution of electrical power throughout the area covered by the powers granted to them by the Legislature. By the aid of these power schemes electrical energy for driving machinery, for traction,

lighting, or any other purpose, will be placed at the disposal of all who may want to employ it, at such prices as will, in the majority of cases, prove more economical than if the power were generated on the spot by the user.

Doubtless this will appear somewhat inconsistent; still, it is perfectly feasible, for in all generating plants, unless the demand for the power generated is continuous and at its maximum, loss in efficiency, which means loss in money, will ensue. The user of electrical energy obtained from these public sources takes it as he requires it. He pays only for what he uses. If he shuts down his works for dinner or any other purpose, he cuts off his electrical power. He has no need to bank his fires. He has no boiler to look to, no engine man or boiler man to pay.

Herein is that which should prove of service to manufacture in Great Britain; but, unhappily, in this, as in most applications of electrical energy, we are not to the fore. That which is destined to serve the public, and consequently requires State recognition, takes time, and so our movement is slow. Other nations, with a more ready appreciation of the value of such a power, or untrammelled with those conditions which prevail with us, have fostered its advancement, and we see Italy, Sweden, the United States, and others rapidly taking advantage of every natural source of power, and extending it near and far.

How is Great Britain to compete with all these advantages enjoyed by others unless she is placed upon a level footing with them? Clearly, if electrical agency has any potency, the effort of the country and the effort of every citizen should be to promote its advancement. What we have to study is the interest of the community at large, not that of a local community. It is only in the concentration of a source of power applicable to many and varied purposes that we reach that stage of economical production that admits of its distribution at such rates as will prove of advantage to the manufacturing industry at large. Probably nothing has contributed more to Britain's commercial success than her railways. In electricity, if applied to its fullest advantage, if relieved of those restrictions which have so far impeded its progress, the country has a power equally potent for good; and if it were dealt with by legislation after the same manner as railways are, without regard to local, district, or other areas, it would more readily place the country in a position to compete with others.

Electricity may aid the manufacturer with power to drive his machinery, but cheap power alone will not fight the fight. Labour is a grave question, and unless the regulations which control it at present are redressed, the British manufacturer must stand at a disadvantage with other employers whose employees work with a will, without limitation. How can the home manufacturer compete with the foreigner when the former is often bound by the conditions attending municipal contracts to observe trade union regulations to which the latter has not to subscribe for that which he produces out of the country? The insistence of the observance of such regulations adds to the home manufacturers' burden, and, worse still, tends to demoralise British labour. In this commercial struggle there are three great factors demanding consideration,—the adoption of the most improved labour-saving machinery, freedom in labour, and greater freedom in the administration of whatever may tend to promote economical production, these to be combined with a State Commercial Department, presided over by a Minister of Commerce, whose duty it shall be to see that, so far as the interests of the country will admit, British production and British trade shall enjoy, at least, advantages similar to those possessed by other countries.

The question is not solely one of manufacture. Behind it stands that of employment for the people. Everything used in the country that is manufactured out of it, and could be made in it at no greater cost, is a loss to the people. In manufacture is the stable support of the working population. Of this we cannot be blind, and no more important question can present itself for consideration.

AMERICAN TRACTION ENGINE NOTES

By Charles O. Heggem

WHEN we consider that more than 8000 traction engines are built yearly in the United States, and the variety of uses to which they are put, it is somewhat singular that so little notice is taken of, or comment made upon, them, either by the engineering press or in the transactions of engineering societies. One will look in vain for reports of tests or other data by which to compare results obtained to-day in the performance of this, to the farming community at least, well-nigh indispensable motor, with those of twenty years ago, during which time the traction engine has been changed and modified to a great extent in order to meet the different requirements of greater economy, greater power, and less weight per horse-power developed than would have been possible with the cumbersome construction of the early eighties.

The motor usually first employed to run threshing machines in a new country is a horse-power, driven by from eight to fourteen horses. This, as the community prospers, is replaced by a portable engine, and this, in turn, by a traction engine, in some cases as large as 30 horse-power.

It is clear that when engines of this size are used, the question of steam economy becomes more important than with engines of only 8 or 10 horse-power. These engines, though primar-

A COMPOUND TRACTION ENGINE BUILT BY THE RUSSELL ENGINE CO., MASSILLON, OHIO, DRIVING A SAW MILL

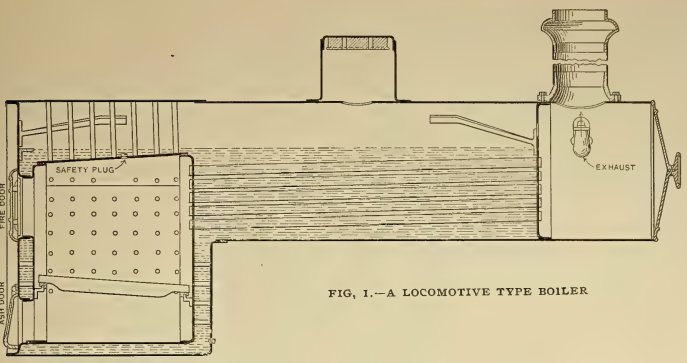


FIG. 1.—A LOCOMOTIVE TYPE BOILER

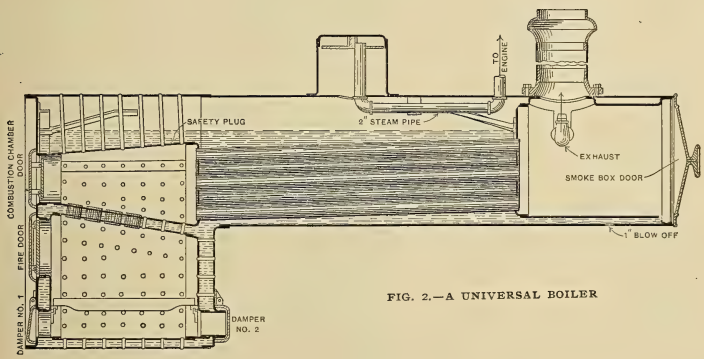


FIG. 2.—A UNIVERSAL BOILER

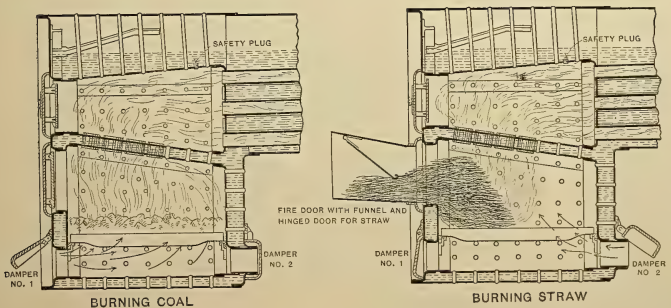


FIG. 3.—BURNING DIFFERENT KINDS OF FUEL

A TRACTION ENGINE MADE BY THE FRICK COMPANY, WAYNESBORO, PA., IN FIELD SERVICE

ily intended to run threshing machines, are put to a variety of uses in different parts of the country. In the North they are used to run sawmills, after the threshing season; and in the South, in

FIG. 4. SCALE 60; INITIAL PRESSURE, 67 LBS.; M. E P., 41 LBS.; WATER CONSUMPTION, 37 LBS., COMPUTED.

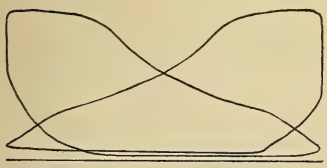
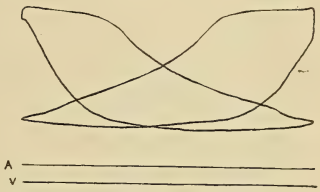


FIG. 5.—SCALE 60; INITIAL PRESSURE, 98 LBS.; M. E. P., 52.8 LBS.; WATER CONSUMPTION, 28.22 LBS.

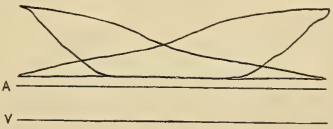
addition to rice threshing, they are used for cotton ginning and other purposes. In some wooded sections they are used to pull up stumps in clearing land. The smallest engines are used in the South, where they thresh about sixty to seventy-five bushels of wheat per hour; while the largest engines are employed in the Northwest and on the Pacific coast, where they thresh from three to four hundred bushels of wheat per hour. The Middle West takes an average size, as they thresh about 125 and 150 bushels of wheat per hour. Oats are there threshed at the rate of about 400 bushels per hour.

After the threshing season these engines are mostly employed in driving sawmills, and the same great variety in output is seen as in threshing. Thus, in the South, from six to eight thousand feet of lumber per day are a good output; while in the Northwest, twenty-five to thirty thousand are the average. Another item that varies greatly is the fuel used,—wood in the North, coal in the East and South, and straw in the West. The furnace of the successful traction engine boiler must burn either kind equally well, and it is astonishing to note how near it comes to meeting these requirements.

As the importance of the economical use of steam has forced itself upon the builders and users of traction engines, boilers have been jacketed, to prevent, as far as possible, loss of heat by radiation, and by better design and construction of valve gear and cylinders it has been possible to reduce the water consumption from fifty pounds to twenty-three pounds per horse-power per hour. At the same time, the boiler has been so improved as to evaporate nine pounds of water with one pound of fuel instead of only five pounds, as was formerly the case. The working pressure has been increased from eighty pounds to one hundred and fifty pounds per square



HIGH-PRESSURE CYLINDER. SCALE, 80; I. P., 138 LBS.; TER. P., 40 LBS.; M. E. P., 46.5 LBS.



LOW PRESSURE CYLINDER. SCALE, 40; I. P., 35 LBS.; M. E. P., 11.9 LBS.; WATER CONSUMPTION, 22.6 LBS.

FIG. 6.

inch, increasing the power of the engine without increasing its weight in proportion. Thus, we have now a weight of engine per nominal horse-power of about six hundred pounds, while formerly one thousand pounds were a fair average weight.

This reduction in weight is a very important item in hilly and mountainous countries, where bridges strong enough

RESULTS OF TRACTION ENGINE ECONOMY TESTS

	Test No. 50	Test No. 51	Test No. 52	Test No. 53	Test No. 54	Test No. 55
Kind of boiler	Univ. Not Jacket'd	Loco. Not Jacket'd	Univ. Jacketed	Univ. Jacketed	Loco Jacketed	Loco. Not Jacket'd
Size and number of boiler	28½" × 6' No. 8663	28½" × 6' No. 8645	28½" × 6' No. 8663	28"½ × 6' No. 8663	28½" × 6' No. 8645	28½" × 6' No. 7877
Kind of engine	Tand. Com.	Tand. Com.	Tand. Com.	Tand. Com.	Tand. Com.	Simple
Size of engine	6½" × 10" × 10"	6½" × 10" × 10"	6½" × 10" × 10"	6½" × 10" × 10"	6½" × 10" × 10"	7¾" × 10"
Time of test	12.30 to 5.30 p.m.	1 p.m. to 6 p.m.	6.30 to 11.30 a.m.	6.30 to 11.30 a.m.	12.30 to 5.30 p.m.	1 to 6 p m.
Speed in revolutions per minute	225	225	225	225	225	225
Average steam pressure above atmosphere in boiler	148. lbs.	145. lbs.	145. lbs.	145. lbs.	145. lbs.	112. lbs.
Average steam pressure above atmosphere at throttle	143. "	139. "	137. "	139. "	140. "	100. "
Average steam pressure above atmosphere in receiver	41. "	39. "	44. "	37. "	37. "	------
Brake load in H.P.—Net	19.93	19.72	17.1	17.5	19.65	28.19
Average I.H.P.—H. P. cylinder	29.1	29.2	26.6	24.7	28.3	25.3
" " —L. P. "	12.98	12.98	13.	10.7	12.22	------
" " —Both "	32.6	32.7	30.16	28.2	31.87	------
Fuel—Kind of coal	W.Va. Run of Mine	W.Va. Run on mine	W.Va. Run of mine	Best Mass. lump	Best Mass lump	W.Va. Run of mine
Total amount burned	467. lbs.	586.2 lbs.	425. lbs.	390. lbs.	506. lbs.	723. lbs.
Amount of ashes and clinkers	100. "	95. "	64. "	44. "	71. "	86. "
Total amount of combustible	367. "	491.2 "	361. "	346. "	435. "	637. "
Amount of moisture in coal	70. "	87.9 "	64.75 "	58.5 "	79.9 "	108.45 "
Total amount of combustible pure and dry	297. "	403.3 "	296.25 "	287.5 "	359.1 "	528.55 "
Water—Total weighed to boiler	3358. "	3458. "	3293. "	3200. "	3230 "	3983. "
Amount consumed per H.P. per hour.	20.9 "	21.15 "	21.83 "	22.62 "	20.2 "	28.22 "
Amount evaporated per lb. of combustible	9.1 "	7. "	9.1 "	9.2 "	7.4 "	6.23 "
Amount evaporated per lb. of comb. pure and dry	11.3 "	8.58 "	11.6 "	11.48 "	9. "	7.5 "
Equivalent evaporated from and at 212° Fahr	12.72 "	9.34 "	12. "	12.48 "	9.74 "	8.3 "
Temperature—Feed water in tank	80° F.	80° F.	75° F.	75° F.	83° F.	84° F.
Water entering boiler	180° F.	174° F.	178° F.	177° F.	179° F.	148° F.

to carry these heavy loads are hard to find. The reduction in weight per horse-power developed is entirely due to the introduction, into the traction field, of the compound engine, which is by far the greatest improvement in this line of work during the period here considered. To this innovation is due also a great saving in fuel, and this means a great saving in water, which, on the prairies of the American Northwest, where the water has to be hauled sometimes for miles, is a benefit that it is hard to overestimate.

Fig. 4 shows a diagram taken from a $7'' \times 12''$ engine in 1882, and is a fair

former in tests Nos. 51, 54, and 55; the latter in tests Nos. 50, 52, and 53.

In Fig. 3 is shown the use of the dampers in burning different kinds of fuel. For coal, requiring the air to be brought up through the bed of fuel, the rear damper, or No. 1, is used; while for straw, in order to burn the ends, damper No. 2 admits the air just right.

It may not be generally known that in burning straw but one grate bar is used. This is made very heavy and placed in the centre of the furnace, leaving a large opening on each side through which to dump the large cinder that forms when this kind of fuel is used.

THE STAR TRACTION ENGINE, BUILT BY THE AULTMAN COMPANY, CANTON, OHIO.

representative of the steam distribution accomplished by the valve arrangement then in use. Fig. 5 gives evidence of a great improvement in steam distribution over Fig. 1, and the contrast is so marked as to make further explanation unnecessary. In Fig. 6 we have the diagrams taken from a compound engine, and here the steam distribution is carried a point further. The table of results on the opposite page, of some economy tests carried on to demonstrate, among other things, the relative value of jacketed as compared with unjacketed boilers, is very interesting. It also shows the relative evaporative efficiency of the two boilers shown in Figs. 1 and 2, the

This single grate bar is made very much heavier than ordinary grate bars, to keep it from sagging when it gets red hot; when in this condition it facilitates the ignition of the straw as it is thrust through the funnel in the fire-door into the furnace. In firing with straw, it is astonishing to one not accustomed to it to see how little it takes to keep up steam and how comparatively easy the firing is.

The evolution of the traction engine road wheels forms another very interesting subject in this field, to be only briefly mentioned here. The wheels have grown from 50 inches in diameter by 6 inches face to 72 inches in diame-

ter by 30 inches face, and some engines are built with wheels 90 inches in diameter and 60 inches face. These latter are used on the coast of California, where the land is low and spongy, making these extraordinarily wide wheels necessary to keep the engine from sinking too deeply into the soft ground.

MACHINE SHOP PHOTOGRAPHY

By Albert M. Powell, B. Sc.

THE photographic department of a modern machine manufacturing plant is considered at present almost as essential and important an adjunct to the successful operation of a concern as the draughting room or tool room. It should, therefore, be fully equipped with all the accessories of a first-class photographic studio, and when the business is such as will warrant the outlay a professional operator should be put in charge. The great majority of manufacturing establishments, however, do not care to increase the scope of this department beyond a simple record of standard machines built at the present time, for the purpose of furnishing photographs to intending purchasers; consequently, an amateur, who may be one of the firm, a draughtsman, or even a workman in the shop, is selected to do the photographic work which may be required from time to time.

It is the writer's purpose here to outline a system of machine-shop photography which is the result of many years of experience in a small way, and is in every way suitable for even the most modest concern to adopt. As to the uses of shop photography,—they comprise, to begin with, the supplying of photographs of the various products of the establishment, to serve advertising purposes. These photographs are usually made from a point of view that will most readily show the machine as a whole, substantially as it would look to an observer standing at its side or in front of it. This does not always give to an intending purchaser any idea of its construction or the arrangement of the working parts. However, it will in many cases be sufficient, though occasionally a prospective purchaser desires to be further informed regarding other points which are only obscurely shown on this general picture, and in order to enlighten him it may be necessary to make such other views as will explain them.

One must anticipate what is wanted, and should photograph the machine from different points of view. Photograph the working parts, often a single part, especially if this part is a feature unique in that particular design of machine,—for instance, on a planing machine, the view looking down into the gearing. This will show how it is arranged and driven. Then there are the feeding devices, the cutting heads as a whole and in detail, oiling devices in tracks, belt-shifting devices, and others, of all of which photographs would be desirable.

In the case of a lathe, photographs would be desirable of the cone head, taken in such a way as to explain its construction and special features; of the carriage and apron, with views showing its working parts; and of the special tool block, taper attachment, or any other device for which superiority may perhaps be claimed over a competitor's design and which it may be desired to impress upon a prospective purchaser. But there are many other things as well which may come to the mind of the intelligent and progressive shop photographer, all tending to increase the value of his department.

Anticipate what your customer may

desire to be enlightened upon regarding your machine, and be prepared with a good photograph to answer his question. It does not follow that such photographs should be sent out broadcast in answer to every inquiry. In fact, it would not be good business policy to do so, as you might be giving your competitor the very assistance he was desiring to get so as to improve his design.

These detail photographs, as we call them, should be in the hands of your travelling men and your selling agents, to be used by them solely for the purpose of selling your goods. Nothing can impress or influence a possible purchaser more than a well-selected lot of fine photographs, showing a machine completely in all its working parts.

Again, photography can be of great use in making copies of standard drawings. These copies may be bound in book-form, each book containing a complete set of working drawings of each machine. These drawings can be easily carried along by travelling selling agents, and, with the detail photographs of the machine itself, most intelligently explain the machine to be sold. Photographs thus made on 8-inch × 10-inch plates and blue printed are of ample size to clearly show all lines and dimension figures, and are much easier to carry about than the large blue prints or tracings of the original drawings.

Again, where certain changes are made in existing types to meet the requirements of special orders, such changes can be photographed and a copy filed with the complete order for future reference, should occasion require it, as in the case of repairs, for example. This applies principally where some change is made or ordered in standard patterns and is made to fill only this particular order, the pattern being afterwards changed back to its original condition.

Photography can be used to advantage also in the pattern room, in making records of patterns, especially in the case of a complicated pattern that it would be difficult to understand or to explain to the foundry man. In the case where patterns are sent to a distance to be cast, photographic records would show just how the separate pieces went together, especially if each piece in the photograph had a number marked on it corresponding to the number on the pattern piece itself. All patterns could be photographed on a small, inexpensive plate, and a print from each pattern could be made a part of the pattern record. If the card index be used for a pattern record, the photograph could be pasted or printed on the back of the record card, and this would show at a glance, even to a novice, the shape and character of the pattern itself, and would aid largely in picking out this particular pattern in the storage loft when occasion required it.

In the foundry, a photograph taken in the process of moulding a complicated piece might be of great value for future reference should the same piece be ordered again, and might be the means of saving considerable money in making the piece a second time, especially if a new man had the making of it.

In the machine shop photography would apply equally in showing the work in its several stages, making a picture record of a complicated machine from the time the first machining was done to the final or completed machine ready for shipment. Of course, it would be desirable to do this only in cases where some special methods and appliances were used which would be of value and assistance should a similar problem arise in future work. A reference to what had been done in the past on similar work might be the means of saving much time and expense.

Regarding the apparatus and methods employed in getting the best results, every photographer has his own pet notions and way of doing his work. He has a preference for a certain make of camera, plate, developer, etc. I do not care to discuss this question, nor do I wish to assert that my way is the best. I propose only to outline the method I follow, as one that has given me the best results in my particular work.

In the first place, a good dark room is indispensable. It should be of ample size, should be well ventilated and " well

lighted,"—the light so arranged as to be readily adjusted to be able to work the quickest on the very slowest plates, or made light enough to see what you are doing when toning or developing. There should be a sink with running water, passing through a filter, and places or shelves at each side for your hypo tank and stock solutions. A rack over the sink is desirable for holding the developing tray and your washing box near at hand. Other shelves should be suitably placed for storage of plates, and a rack for storing negatives, drawers arranged to keep supplies, paper, etc., with a broad top, to be used as a table.

If possible, arrange this room so as to enable you to do all your work in it, except the printing. Don't allow a lot of unlabelled or empty bottles or boxes to accumulate. Keep everything perfectly clean about the place. Have a place for everything and keep everything there. Select one brand of plate that you have found to work well in your particular work and stick to it. The same advice can well be applied to the developer.

On machinery there is so much light and shade that great care must be taken to light it properly. If possible, place the machine where the light comes in from the north, but not where the strongest light comes from the top. The upper part of a machine is usually made up mostly of bright work, and will be over-exposed before the lower portion, which is usually dark, painted work, has had normal exposure; therefore, it may be necessary to screen or cut off top-light and reflect light into the darker parts of the machine, so as to give uniform lighting.

I find it desirable, where there is much bright, polished work, to dull it by taking a ball of putty and tapping it over the bright work. This deadens the polish. This is necessary only where there is strong reflection. It is not desirable to have the picture too flat. Contrast makes an effective picture. Painting the castings a light colour makes a very attractive picture, but the idea of a machine photograph is to give a picture which looks like the finished machine, and this is not the case where light paint is used. I find that by cutting off the top-light and reflecting light into the dark portions of the machine I get a picture which is very satisfactory.

Reflectors can be made of frames covered with white cloth, or paper preferably, which can be placed at such angles as to throw a large amount of light on to the machine in the places where it is most needed. The foreground should be prepared by laying clean white boards on a level with the feet of the machine, extending well in front, at each end, and at the rear as far as possible, so as not to show the joining with the screen. The screen should be carried back of the machine far enough to be out of focus, and if at all soiled, it should be kept in motion. A gentle swaying sidewise will be sufficient to make a clean background. Great care should be taken to keep this screen clean and to keep it far enough away from the machine so that no shadows are cast upon it, as this will greatly facilitate blocking-out or painting out the background on the finished negative. This blocking-out is necessary if a pure white background be desired.

Usually the machine has the maker's name cast on it, as well as pattern and piece numbers. These can be prominently brought out by rubbing them over with chalk. Ordinarily, a well-exposed and developed negative requires no retouching. If, however, it should be necessary, my advice is to take it to some professional retoucher, and, at slight expense, have it done properly. This is a trade in itself, and it is cheaper to have it done than to learn the trade.

A long-focus lens I find to be the best, as it gives better definition and less distortion than a short-focus, wide-angle, especially if the machine to be photographed is long and narrow. The lens should be absolutely rectilinear, otherwise the straight lines in the machine will be curved and the whole machine distorted. Oftentimes, however, a cheap lens will give good enough definition and prove quite as satisfactory as a very expensive one. The box should be good and strong, and the tripod on which it is mounted should be heavy

and rigid, so as not to vibrate or jar and so blur the picture. Stop the lens low down and expose for the shadows and develop slowly, and, if necessary, accelerate development where it is weak. Continue development until all detail is out and there is sufficient density and contrast to give a good print.

Do not get the plate too dense, as it makes a hard "printer," and one that has too great contrast to be satisfactory. Regarding length of exposure, development, etc., one must be governed wholly by his own particular surroundings and conditions, the kind of plate used, the size of the stop, the time of the year, the hour of the day, and the value of the light on the work.

Current Topics

ALTHOUGH to many who have given the subject of wireless telegraphy close attention the feat of transmitting recognisable signals across the Atlantic has not been deemed impossible of accomplishment, the recent announcement of Marconi's success in this direction appears to have produced as profound an impression on the public mind as though wireless telegraphy had been just heard of for the first time, and almost as though a regular interchange of business had already been established by its means, while, in fact, the experiment has barely passed the stage where Marconi's self-constituted critics and competitors are deterred from offering the suggestion that individual errors, augmented by the wishes of the heart, may have accounted for the results alleged to have been obtained. But Marconi's honesty cannot be questioned, and while, doubtless, he is an enthusiast, and properly so, it is well known that his enthusiasm is tempered with sufficient conservatism to give him equipoise, and, therefore, the original suggestion of his critics that he may have mistaken the effects of atmospheric electricity for his prearranged signals from Cornwall was not entitled to much consideration.

ANOTHER factor, however, has been introduced since the announcement of Marconi's reception of the letter "S" in his specially constructed, sensitive telephone receiver, and that is the threat of an injunction by the Anglo-American Cable Company to prevent Marconi from using Newfoundland as a base of telegraphic communication with Europe, and as a result of this threat Marconi

has ceased operations in Newfoundland, and will continue them in Nova Scotia, and at Cape Cod, in the United States, where he will have every facility for his experiments. There are, perhaps, two reasons why this interference on the part of the Anglo-American Cable Company may not be altogether displeasing to Marconi. One is that it avoids the need of proving to disinterested witnesses, whose hearing might not be of the requisite acuteness, the actual reception of the signals; another, that he is so well assured of success that he prefers to continue his experiments between England and the mainland of America, the additional half thousand miles, more or less, to Nova Scotia, possibly not weighing very much, especially if Marconi sees his way clear to the employment of largely increased power at the transmitting station, and it certainly is of great importance to dispense with a relaying station in Newfoundland if such a thing is at all feasible. In the meantime, Marconi has the satisfaction of knowing that his efforts are heartily appreciated by the Government of Newfoundland, which has very properly intimated that the matter of demonstrating the possibility of wireless telegraphy across the Atlantic Ocean,—a matter of the most intense scientific interest,—and the actual transmission of messages as a business by the Marconi system, are two very different propositions, the one to be encouraged by every means available, the other to be considered at the proper time, which, the Governor and his Cabinet observe, has not yet come.

Doubtless we shall now hear of another fall in the price of Atlantic cable stocks, such as took place when the public announcement of Marconi's first successful results were made, or like the fall in gas stocks that occurred when Edison announced his successful subdivision of the electric current for electric lighting purposes. It will be only the most timid, however, whose judgment will be affected by Marconi's new announcement. There is probably far less reason to apprehend any marked effect upon the earnings of the Atlantic cables by the competition of transatlantic wireless telegraphy than there was in the other case mentioned, and in that case, although electric lighting is to-day an abundant success, gas stocks were probably never so high as at present. So far, then, as the effect of the successful accomplishment of transatlantic wireless telegraphy in its present form upon the stock dividends of the Atlantic cables is concerned, it may be neglected. Doubtless the glamour of the thing will attract some of the unthinking, and the relative cost of a wireless outfit station or two, —$60,000, as given out by Marconi,— as compared with several million dollars for a cable, will afford a basis for the exploiters of other wireless telegraph companies than Marconi's to predicate seeming large profits. And granting that telegraphing across the Atlantic without wires were an accomplished fact, which assuredly it is not yet, and further that vagrant waves from passing ships and elsewhere and other causes would not disturb its regular and reliable operation, the prospect is rather an alluring one.

So much has been heard latterly of the ascendency of American manufacturers in many different branches of industry over those of Great Britain and other countries as to make it a bit refreshing, in the way of variety, to note that in the matter of long submarine electric cables British, French, and German makers have hitherto retained supremacy over those of the United States. Indeed, it is a matter of no little moment to American cable makers that the promoters of the Pacific Commercial Cable Company appear not to have given them more than a passing thought in the recent placing of the order for this cable. But it can hardly be gainsaid that American cable manufacturers are not yet in a position to undertake the construction of a cable of the extent and quality of the one in question. British and Continental deep-sea cable manufacturers have, it may be said, grown

up with the business, and as a result they have the machinery, and, most important, the expert knowledge, necessary in the manufacture of such cables. Furthermore, much of this expert knowledge is a trade secret, and is claimed to be of such a beneficial nature that, given the same quantity and quality of material, the exercise of this knowledge in the course of manufacture will enable one manufacturer to guarantee a speed of signalling over the cable considerably greater than could another manufacturer not possessed of similar knowledge. Besides, the time consumed in the making and laying of a cable such as the proposed new Pacific cable is so great, —from three to four years,—and the outlay incurred is so enormous, about $15,000,000, or £3,000,000, that even if a manufacturer without reputation for successful work of this kind should be willing to bond himself to the full amount of any actual loss in the event of failure, no wise purchaser would be justified in taking the risk, however slight, of failure. It would, therefore, seem that until the American cable manufacturer can establish such a reputation, by constructing and laying cables, for the government, for example, it is likely that British and Continental makers will continue to get the bulk, if not all, of the contracts for long deep-sea cables required by purely private corporations.

Among the causes assigned for the inability of American cable manufacturers to compete with other deep-sea manufacturers are the difference in wages and the lack of cable-laying ships. To offset the latter difficulty, it is urged that the United States Government adapt to this work some of the ships used as transports and cruisers during the late war with Spain. To overcome the difference in wages it is proposed in some quarters that a protective tariff be imposed upon the entire length of a cable ending in American territory and not only upon so much of it, say, three miles at the shore ends of the cable, over which at present the United States may fairly claim jurisdiction. Such a tariff would, doubtless, give American manufacturers a monopoly of the construction of cables ending at both ends on United States territory; but as retaliatory tariffs could be placed upon American-made cables landing on foreign soil, this would, perhaps, narrow, rather than broaden, the American manufacturer's market. Indeed, the effect of such a tariff would probably be merely to curtail the extension of cables in so far as an increased cost of cable would so curtail the extension, for the present existing feeling that appears to prevail concerning the inability of American manufacturers to successfully compete with foreign manufacturers would still remain to be surmounted. The most probable result of such a high tariff would be the establishment of branches of foreign deep-sea cable factories in the United States. Somewhat singular, in view of the foregoing, is the fact that the British cable manufacturer has not always been equally successful in competition with his American cousin for the work of making underground cables for electric traction purposes in Great Britain. Quite a number of the large contracts in this line have gone to American manufacturers in the last three or four years, and only recently another contract, amounting to about £35,000, for electric cables for the Glasgow tramways, has been awarded to a New York maker.

Some measure of the extent to which mechanical stokers are now being applied to steam boilers is furnished by what is being done in connection with several of the large power houses at present going up in New York. At the Manhattan Railway power house, for example, the total installation, when the plant will be completed as designed, will be 384 stokers attached to ninety-six 525-H. P. boilers,—a total of 50,400 H. P. The present installation of 256 stokers on sixty-four boilers, figuring up 33,400 H. P., will be equalled by the new plant now being erected for the New York Edison Company, compris-

ing 35,000 H. P. of boilers with 244 stokers, while two other large plants under construction,—the Third Avenue Street Railway Company's station and that of the Metropolitan Street Railway Company,—will have, respectively, 31,500 H. P. of boilers with 240 stokers, and 25,000 H. P. with 174 stokers. The saving of manual labour accomplished by these equipments is, in itself, an item of no mean importance, though it is only one of their advantages.

One of the latest systems of ship's bulkhead doors has been installed by the North German Lloyd Steamship Company on several of its vessels, among them the *Kronprinz Wilhelm*, on which an exhibition of the working of the apparatus was recently given. The system, known as the Dörr system, by the way, is not unlike at least one other, proposed and used in recent years, in which all the doors, of a vertically sliding pattern, are opened and closed by hydraulic power controlled from a central station,—in this case the commander's bridge. It is this central station control which constitutes the real virtue of the whole outfit, as it avoids the dangers of forgetfulness or loss of presence of mind at times of greatest need. The operating pressure is applied by turning a wheel on the ship's bridge, but before such turning a trip lever must be moved out of the way, and this takes about twenty seconds of time during which electric bells are sounded at every door, giving warning of the fact that the doors are presently to be closed. Each door, moreover, can be closed by hand, independently of the hydraulic attachment, and is provided with a lever by which it can be made to drop into its closed position almost instantly. A system of electric signals has further been adopted in connection with the doors all over the ship. This provides for the officer on watch, at his station, a large diagram of all the decks, and at each point where there is a bulkhead door a small bull's-eye is placed. Behind these bull's-eyes are signal lamps so connected to switches at the doors that whenever a door is closed the lamp is lighted. The position of the bulkhead doors throughout the entire ship is thus immediately under the eye of the officer in charge. The system is ingenious and simple enough to promise good service.

There is no disguising the fact, however, that a door in a bulkhead is always an element of weakness and danger; indeed, the only safe bulkhead, as some very able experts have contended, is the bulkhead that has no doors. Most ship captains and engineers, on the other hand, say that they must have doors, and the best solution of the question, therefore, would seem to be a reduction of the number of doors to a minimum, the selection of a good type of door, and the adoption of a safe means of operating it, and as to this last feature,—it appears to be afforded by a central station method like the one just noted.

One form of bulkhead door, a "never-open" door, as it was aptly called, which was brought out several years ago and was illustrated and described at the time in these pages, may be referred to again with possible interest in connection with the paragraphs preceding. It is not now recalled whether that particular door was applied practically to any extent, but it certainly had the virtue of not requiring any human or any mechanical agency to keep it closed; in fact, it was never open. Strictly speaking, the door was not a door at all, but a cylindrical casing, bolted to the water-tight bulkhead, one-half of the cylinder being in one compartment and the other half in the compartment adjoining. In this casing there were two doorways, one at the fore part and the other aft. Within the casing, and fitting closely, was a hollow cylinder, revolving easily, having one doorway in its circumference, of a size corresponding to that of the doorways in the outer casing. This cylinder was

suspended from a central bolt overhead, and could be revolved by hand, slots for inserting fingers being provided for this purpose on the outside and handles on the inside. When it was desired to pass through a bulkhead, the opening in the revolving cylinder was brought around to correspond with the doorway in the casing, the person stepped inside, revolved the cylinder, and, in doing so, of course brought it around so that its one doorway corresponded with the doorway on the opposite side of the casing, thus giving egress into the compartment. The doorway by which entrance was had to the casing was, of course, absolutely closed before the revolving cylinder and its opening came in line with the opposite doorway allowing egress from the casing. The principle of the thing was somewhat like that of the familiar air lock used in pneumatic caisson work.

In a speech at Chicago, a short time ago, at a banquet of the Bankers' Club, Mr. Charles M. Schwab, the president of the United States Steel Corporation, —the billion-dollar "trust," as it has been dubbed,—declared "trusts" to be dead business propositions, built on a trinity that would wreck anything,— the restriction of trade, the increase of prices, and the throttling of competition. In distinction from the "trust" he declared that business consolidation had for its guiding principles the reverse of this trinity. "The consolidation, as organised to-day," he said, "instead of restricting trade, expands trade by creating new avenues and reducing the price of the commodities which it produces. It is enabled to do this because the chief advantage of consolidation is the reduction in the cost of the articles produced. In years gone by if you have looked at a diagram of fluctuations in prices you have found it a series of valleys and peaks. These great consolidations will keep that on a level. To-day the demands for steel, for example, are so great that an individual concern would undoubtedly have put the price 20, 30, or even 40 per cent. higher than it is now. What would have been the result? People with enterprises in their mind would have hesitated and would have said:— 'Wait, we will buy it a little cheaper later on.' What would have been the result of that? Construction would have been stopped. Builders would have waited for lower prices; railroads would not have extended until they could have done better, but now we believe we are getting the confidence of the public in that respect. The result will be that building will go on; railroads will be developed, and business generally will be on a more permanent and level basis."

WILLIAM ELLIS COREY

President of the Carnegie Steel Company

A BIOGRAPHICAL SKETCH

Of the notable thirty young men who, through remarkable ability in various lines, have in recent years been admitted to partnership in the Carnegie Steel Company,—the "Great Carnegie Thirty," as they have been termed,—William Ellis Corey today occupies one of the foremost positions, having last year became president of the company in place of Mr. Charles M. Schwab, who, in turn, assumed the presidency of the United States Steel Company.

Mr. Corey has been identified with

the steel industry for nearly twenty years, and has been in the service of the Carnegie interests all of that time. He was born on May 4, 1866, at Braddock, Pa., where his parents still reside, and attended the common schools until he had reached his sixteenth year, when he secured a position in the laboratory of Carnegie's Edgar Thomson Steel Works. His commercial education was received in Duff's College, Pittsburgh. He also studied chemistry at home, and mastered the theory and practice of metallurgy so thoroughly that when the responsibilities of management came with his appointment to official position he was in every way qualified.

From the Edgar Thomson laboratory he was transferred to one of the plate mills of the Homestead Steel Works. He was made superintendent of the plate mill at the age of twenty-two, to which position the duties of open-hearth department and slabbing mill superintendent were also added. His next advance was to the position of superintendent of the armour-plate plant, which he filled until 1895, when he was made general superintendent of the Homestead Steel Works, embracing the direction of the Carrie furnace plant when the Carnegie Company secured that property, and the Howard Axle Works, when it was established.

While in control of the armour-plate department Mr. Corey invented an improved process of manufacturing armour, which is known to ordnance engineers as the Corey reforging process, by which the ballistic resistance of armour was greatly increased and the weight of plate to be carried by a ship considerably reduced.

Mr. Corey was elected to the office of chief executive of the Carnegie Company and Carnegie Steel Company on April 16, 1901. His administration of the various official positions he has filled has been singularly successful, and is largely due to the fact that he held the confidence and good-will of the thousands of workmen with whom he has been associated. He is a member of the Duquesne and Country clubs, of Pittsburgh, and of the Lawyers Club, of New York City.

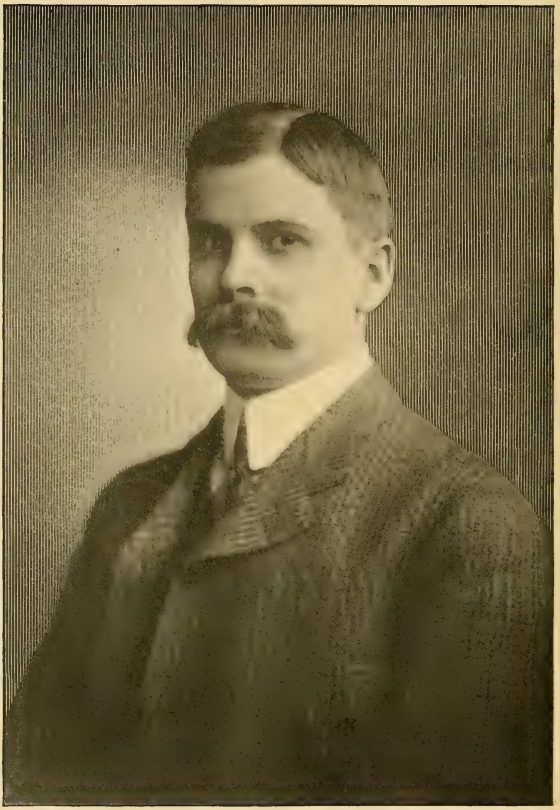


PHOTO BY RADNOR CONVER, CHICAGO

Bion J. Arnold

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TELPHERAGE

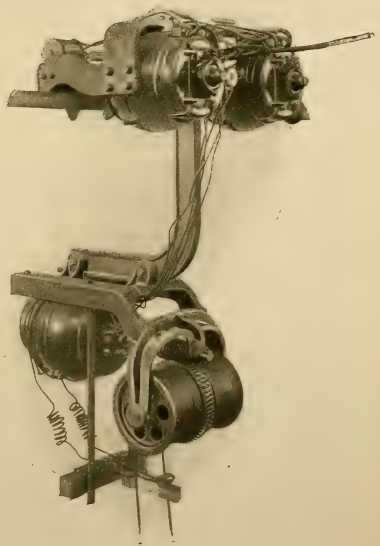
A SYSTEM OF ELECTRIC TRACTION

By A. S. Clift, M. E.

TELPHERAGE, or the automatic transportation of material by electricity, is by no means a new branch of engineering. In fact, it seems odd, in reviewing it, that some of the earliest work in electric traction should have been carried out on this plan, telphers, running on overhead cables, being employed to haul trailers carrying various kinds of materials.

Some of the earliest investigations and experiments were made in Great Britain as early as 1882 by the late Prof. Fleeming Jenkin, and much pioneer work on the subject was also done by Prof. John Perry and Prof. W. E. Ayrton. In the words of Prof. Jenkin, who coined the name, telpherage is the "transmission of vehicles by electricity to a distance independent of control from the vehicle." The word is derived from the Greek words meaning far-carrying, the first syllable being of the same derivation as that in telegraph and telephone.

As the original work was confined mostly to overhead lines, the meaning of the name gradually became restricted to these. Laterally, however, the word has been restored to its original meaning; and, in fact, many of the features, particularly in the method of control, are common to aerial, surface, and underground, or tubular despatch, lines. Space, however, does not permit taking up in this article more than the principal features of construction and some of the uses of aerial telpherage. Interesting as was the original work



A TELPHER WITH AN ELECTRIC HOIST SUSPENDED BELOW

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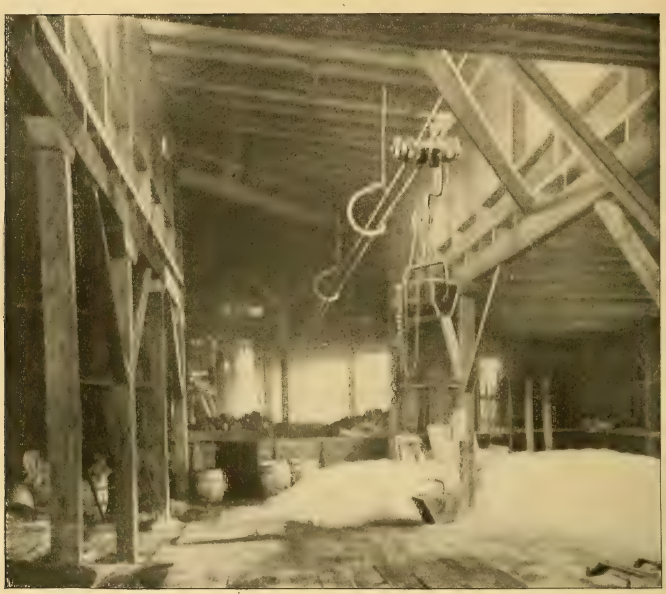


A TELPHER LINE IN A GLASS WORKS

from a scientific standpoint, it met with little practical success, and, indeed, this is not to be wondered at when we consider the crudeness of the electric motor at that time, and how obscure were then what are now the most elementary principles of electric traction. Thus, for several years after the first experiments, and while other branches of electrical work were advancing by great leaps, telpherage remained practically inert, and it is only comparatively recently that the subject has been revived and brought to what may be termed a successful status by the application of the principles which have been found satisfactory in the operation of electric tram lines.

Aerial telpher lines may be of either cable or rail construction, the former being far more common, and the latter, on account of its high cost, being confined to relatively short lines where heavy loads and special conditions warrant its use. The rail construction, however, is frequently resorted to also for terminals and curves.

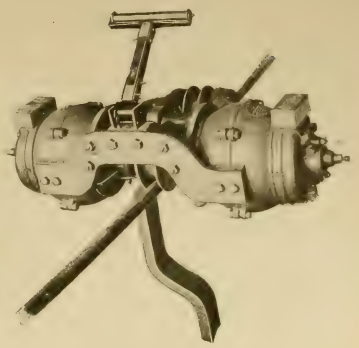
The cable line consists essentially of a steel running cable, fixed upon poles, and supported at points between the poles by means of curved hangers from an upper or suspension cable, which prevents excessive sagging. The spacing of the poles varies with the load, a distance between poles of 100 feet being common for light lines, while for heavy loads a lower cost and increased stability are secured by setting the poles closer together and having fewer intermediate points of support for the cable. Long spans, such, for example, as are required in passing over streams or ravines, are made by increasing the height of the adjacent poles, making them, if necessary, in the form of structural steel towers, and increasing the dip of the suspension cable and the number of hangers.

Careful attention must be given to the method of clamping the cable at the

points of support, for the construction should be such as to afford secure support to the cable and still allow the telpher to pass smoothly from one span to the next. The trolley wire is run a short distance above the running cable, being suspended on insulators fixed on the hangers, and on suitable brackets at the poles. In long lines the trolley wire is supplied with current at several points in the usual manner by means of feeders.

The electrically-driven carrier which runs upon the cable is called a telpher, and is of the simplest construction. There is no gearing, the grooved wheel which runs upon the cable being fixed directly upon the motor shaft, which is made large in diameter and runs in amply proportioned bearings adjacent to the wheel, to sustain the total weight of the motor and load.

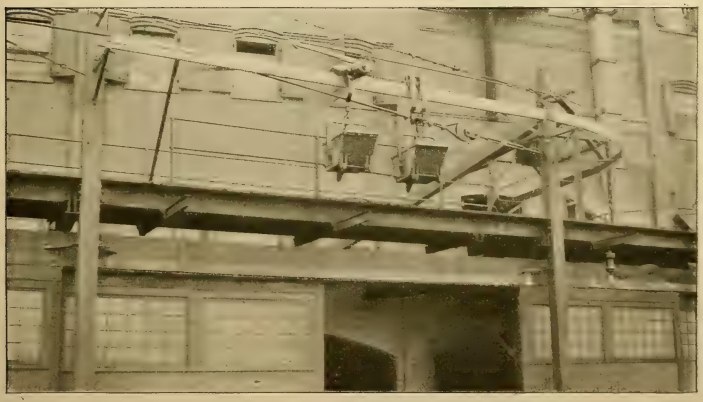
The most common and probably the most suitable form of telpher for light work consists of two motors placed on either side of the grooved driving-wheel, with an idle trailing wheel, mounted on a light but rigid frame, from which the load is suspended, as shown above. Four motors may be employed, two being placed on either side of each wheel, as shown on page 368. Such a construction is, however, more costly. Telphers of either of the above forms



A CENTER-BEARING TELPHER

are known as "centre-bearing," because the support on the cable lies in the centre or between the motors.

Another form, known as a side telpher, consists in placing the motors on one side of the cable only, as represented in the engraving on the opening page of this article. In the telpher shown in that illustration the weight of the motors is balanced by an electric hoist suspended below them, but on the opposite side of the cable. Such a construction permits of a reduction in the depth of the curved



A TELPHER LINE WHICH HANDLES THE ASHES OF A 6000 H. P. STEAM PLANT

HERE THE ASHES FROM THE BOILERS ARE RAISED 35 FEET AND TRANSPORTED OVER A TELPHER LINE TO A HOPPER, WHERE THE LOAD IS AUTOMATICALLY DUMPED

hangers, and their weight as well may be thus greatly diminished.

Projections from the telpher frame, so placed as to hook over the cable should the wheels run off, make it practically impossible for the telpher to fall to the ground in case of such an accident. In connection with this, however, it may be of interest to note that derailing, or, more properly, "decabling" of a telpher is practically unknown. The line being overhead, there is little chance of obstruction, and an occasional dead branch of a tree is about the sole cause of trouble. At all events, the tendency of the telpher to "stick" to the cable is remarkable. But this feature is not secured without suitable means of supporting the load, so that it shall be free to swing, pendulum fashion, in the direction of motion without causing the telpher to "buck," and equal care must be exercised in the design of draw-bars for trailers.

DIAGRAMS OF A TELPHER LINE INSTALLATION

The carriers, which are suspended either directly from the telpher or from a hand or electric hoist on the telpher, as conditions may warrant, are of various forms, to suit the nature of the load. There are, for example, ore and earth carriers; flat carriers, suitable for bales and bulky articles; different shapes of hooked carriers for barrels, sacks, and timber; while the automatic self-dumping bucket has a wide field of application. The construction of these carriers is, in most cases, similar to those ordinarily used for the same purpose with cable-haulage lines. Trailers are often employed where the grades encountered are not too steep, and where it is desirable to distribute the load over several points on the cable. They are also useful where the loads are long, as in the case of sticks of timber.

The control of the telpher upon grades is of extreme importance, and many difficulties presented themselves in the design of a brake which would be entirely automatic in its action and which would suitably retard the speed of the telpher upon down grades. The problem, however, has been satisfactorily solved by the use of an electric braking device which acts automatically, with varying degrees of force, depending upon the grade and the speed at which the telpher is running. The surmounting of moderately steep grades presents no difficulties, for the tractive power of telphers of the ordinary construction, such as are shown in the illustrations, running upon a flexible cable, is remarkably high. Such telphers, under test, have been run up grades of not less than 30 per cent., and not even when the cable was

CARRYING SUGAR

AND CEMENT

wet was there any tendency toward slipping

In the planning of telpherage lines there is opportunity for a great diversity of arrangement, to meet the special conditions arising in each case; but certain general principles may usually be applied. Naturally, the first consideration is the division of the total material to be carried among the several telphers or carriers. This fixes the number of telphers and trailers, the load to be carried by each, and the size of cable and supports. In general, it is desirable to divide the total weight between as many telphers as is practicable, especially in the case of long lines, and in such instances it is almost always found necessary that the cable should form a complete loop or double line for the return of the empty carriers. The forward and return cables are supported on the same line of poles, one cable being placed on either side.

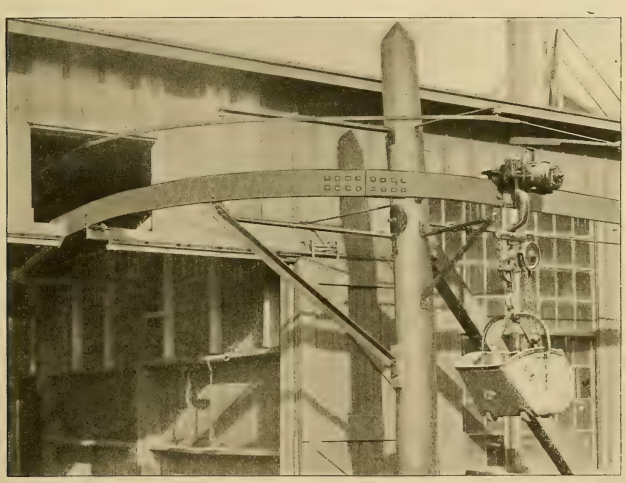
Telpher lines of this description find a useful field of application where material is to be transported to a considerable distance, and where the total traffic is not sufficient to pay for the construction of a railway. In rough and outlying districts, too, the laying of even a narrow-gauge railway is often attended with many difficulties, while overhead lines, being independent of the contour of the ground, may be run with comparative ease and at much lower cost. Telpherage has, therefore, found a wide range of application in mining and lumber districts, and also for conveying sand, clay, bricks, fertilisers, and many other classes of materials which often have to be carried for several miles to railway or waterside.

Telpher lines have also been installed with success for plantation work. Here the commodity to be carried is usually light, being fruits, grain, coffee, tobacco, and other agricultural products, and it

is, therefore, often possible to distribute a large bulk of material between a telpher and several trailers. In fact, such conditions are practically ideal for the use of trailers, and the produce may be conveniently dispatched at somewhat longer intervals by trains, each consisting of a telpher and several trailers.

It is almost unnecessary to add that for such lines it is desirable to reduce the dead weight of the telpher to a minimum in order to keep down the cost of the line, and, therefore, any hoisting devices are usually best omitted from the telpher, stationary hoists being placed at the terminals or intermediate loading points, if required; or it frequently happens that the line may be brought down at an incline at the terminals, thus dispensing entirely with the necessity for hoists. In the case of shorter lines the conditions are changed,

A ready and growing field for telpherage has been found in manufacturing plants, for transmitting light articles, such as small castings, or parts of machines, from warehouse or foundry to the shops, and where the plant consists of buildings located some distance apart. Where the location is upon a waterfront the system is particularly applicable, on account of the ready means which it affords for conveying material between vessels and warehouses without interfering with surface traffic. Thus, for example, coal buckets may be hoisted directly from barges and hooked upon a telpher, which transfers them, at a speed of from eight to twelve miles per hour, to the bins where the buckets are automatically dumped. In such cases an arrangement which is commonly found to meet the requirements consists in running one side of a simple loop line

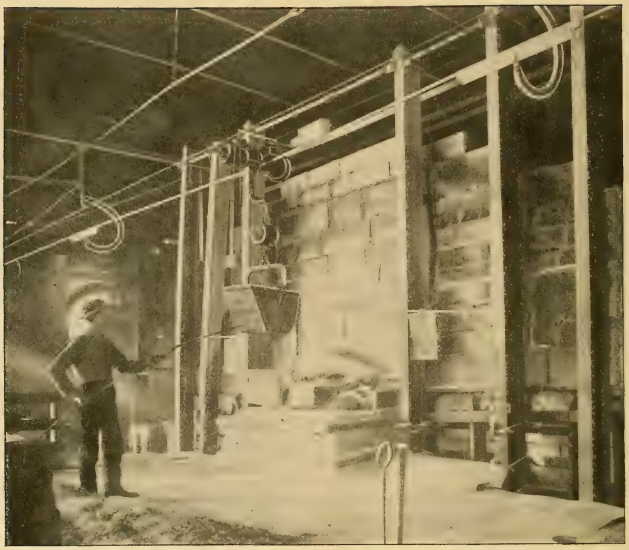


A STEEL WORKS TELPHER LINE. THE BUCKETS GO TO THE END OF THE LINE, AROUND CURVES, AND ARE AUTOMATICALLY DUMPED, REVERSED, AND RETURNED BY SIMPLY MOVING A SWITCH

and in consequence the methods adopted often differ considerably from those employed for long-distance work. The uses to which short lines may be applied are almost too numerous to be mentioned.

along the wharf edge at such an elevation as to be clear of all surface traffic, the other side of the loop being carried alongside or through the warehouses.

In order to stop the telpher at any



CARRYING SAND TO A GLASS FURANCE

desired point, the trolley wire is divided into a number of sections, each controlled by a switch conveniently located. By opening any switch the current is cut off from the corresponding section, and the telpher will stop when it reaches this point. It is again started by closing the switch. At curves a section of the trolley wire is connected to the source of current through a resistance, which lowers the voltage across the motors at this point. Thus, upon approaching a curve, the telpher automatically slows down, runs slowly around the curve until it passes the resistance section, and is then automatically accelerated.

An example of the application of telpherage for factory work is shown on page 371 which illustrates a short line installed at the works of the Yale & Towne Mfg. Company, Stamford, Conn., U. S. A., by the United Telpherage Company, of New York and London. The system is there used for carrying goods to the packing and shipping department, which is in a building a short distance from the main shop. Formerly the carrying was done with hand trucks, and the illustration shows how these are still used for carrying to the telpher line, the telpher then picking up the hand truck bodily with its load.

This installation is interesting from the fact that as the works were already equipped with a two-phase power plant, it was decided to use the same system on the telpher line. Two-phase induction motors are employed, which necessitated the use of two trolley wires, as shown in the illustration, the connections of the circuit being two-phase, three-wire, the running cable acting as a common return. The arrangement for a three-phase system would, of course, be very similar.

An incidental advantage which the alternating system possesses over the direct current lies in the ready means which it affords for reversing the direction of motion of the telpher from any point of the line. This is a valuable feature for some classes of work. The reversal is effected by a simple switch which interchanges two of the phases.

There are difficulties, however, in the way of reducing the speed at curves, and for general use the direct-current system is preferable.

An indoor telpher line, for use in a boiler room, is shown on page 366. The system in this instance is used for conveying ashes from the several boilers to the ash dump, which is at the end of the building. The telpher is equipped with an electric hoist and a self-dumping bucket, which automatically dumps the ashes into a chute leading through an aperture in the end of the building to the ash dump without. Two other illustrations show the system as applied in a glass works for carrying the sand mixture from the mixing room to the furnace, where the mixture is delivered directly over the furnace mouth. A self-dumping bucket also is employed in this instance.

Another class of work to which telpherage is admirably adapted is found where it is required that material should be taken from one or more loading points and distributed over a wide area, in a lumber yard, for example, where the lumber is received on a railway siding, or pier, and is to be delivered upon stacks covering a large space of ground. The most convenient method here consists in running a loop line of heavy cable or rail construction completely around the enclosure, the loop line being also arranged to run through the loading points. A series of lighter lines, parallel to one another, are then run across the enclosed space, dividing it like a gridiron. These auxiliary lines are so arranged that loaded trailers may be conveniently switched on to them from the main loop line, and are also given a slight incline, made just sufficient to allow the trailers to run over them by gravity. The trailer being unloaded, is run down to the low end of the gravity line, where it is again switched on to the main loop line and carried back by the telpher to one of the loading points.

In such an arrangement, if the loads are at all heavy, it is best to have an operator on the telpher. This, however, is one of the comparatively few cases, even in heavy lines, where the attendance of an operator on the telpher is required. In the great majority of instances the system of automatic control is sufficient to meet all practical requirements.

A TWO-PHASE LINE

Summing up the chief features of telpherage and the advantages which it presents, it may be said, to begin with, that its automatic operation, made pos-

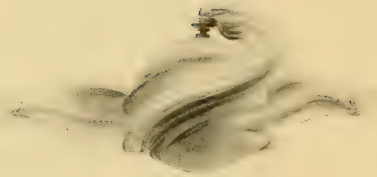
sible by the use of electricity, is one of its greatest points of merit.

Another feature, common, by the way, to all overhead cable systems, is its independence of surface conditions or obstructions, which makes the crossing of rough country, with moderate-sized ravines, or streams, a matter of comparatively little difficulty.

The working speeds attainable are high, a rate of twelve miles per hour on straight sections having been found entirely satisfactory in practice; while it is probable that there would be no difficulties in the way of attaining far higher speeds where the conditions are such as to make them of advantage.

The simple manner in which corners may be turned is a distinctive feature of telpher lines.

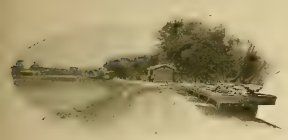
All these, with the low cost of operation and maintenance, and its great flexibility, make the system an ideal one for a large range of work. In view of its use of old and well-understood principles which have met the test of practice, and the success which has been met with in the lines already installed, it is reasonable to look forward to a much-extended employment of the system.



LIGHT RAILWAYS IN EGYPT

By James Albert Wells Peacock, Chief Engineer of the System

Mr. Peacock's paper originally was presented at one of the meetings of the Institution of Civil Engineers. It has been specially revised, however, by the author, for reproduction here, and hitherto unpublished photographs are now given with it.—THE EDITOR.



IN the following paper is presented a short account of a large system of light railways in Egypt, of 2 feet 5½ inches gauge, the total length of which when completed will be about 500 miles. The lines are designed to form feeders to the main lines, and, in general, have been laid alongside the roads.

It may be well, in the first place, to describe briefly the part of the delta of Egypt referred to, in order to give a general idea of the districts served. The delta of Lower Egypt is divided, for administrative purposes, into a number of provinces, of which the two served by the Egyptian delta light railways are the Behera and the Gharbieh provinces, as shown in the map on page 376. To facilitate the settlement of questions relating to railway matters, the Egyptian Government, in granting the concession, roughly determined limits to the provinces with reference to certain fixed points, and these do not strictly accord with the actual administrative limits. The Behera province is considered to be practically bounded on the north by the southern boundaries of Lakes Edkou and Mareotis, on the east by the Rosetta branch of the Nile, on the west by the Lybian desert and eastern boundary of Lake Mareotis, and on the south by the Lybian desert. The Gharbieh province is bounded on the north by the southern edge of Lake Borollos, on the east by the Damietta, on the west by the Rosetta branch of the Nile, and on the south by the main line of the Egyptian State railways.

The soil of the Behera province, with

ENGINEERS' CAMP ON THE LINE

THE DAMANHOUR SWING BRIDGE

the exception of a strip along the Nile, is chiefly "black cotton" soil, and in the desert is sand. This sand, however, on being irrigated by Nile water and well drained, becomes in a few years very valuable land, and yields very good crops. The northern part of the Gharbieh is also chiefly "black cotton" soil, while the southern part is, in places, especially near the canals and high grounds, more or less an alluvial deposit from the Nile. The principal crop for export is cotton, but there are also grown, principally for local consumption, maize, wheat, barley, etc., and, as a winter crop, clover for pasture.

Prior to the year 1890 the provinces were practically without any means of communication with the outlying towns and villages, the only roads, especially in the Behera, being village tracks and the banks of small canals. The Gharbieh having larger canals, some of which were navigable, their banks were used principally as roads, with the usual footpaths through the villages. In that year the government, wishing to improve the means of communication, commenced by making agricultural roads in the Behera, a special tax being put on the estates in the part of the district served, and, as a measure of economy in the first instance, the existing paths and canal banks were utilised. It was also desired to avoid the division of small plots of land as much as possible, especially in the case of small proprietors. The original section of the actual road was 16 feet 5 inches in width at the surface, with an average height of about 1 foot 8 inches above ground level, and for the construction of the roads in the Behera province the government took over a width of 36 feet when going through cultivated lands and 29 feet 6 inches when on canal banks. The section of the road was formed so that the "borrow pits" at the sides were utilised as side ditches, and at the same time formed boundaries.

After finding that these roads were so greatly appreciated by the public, the government decided to extend them to the other provinces, and in May, 1896, a decree was issued authorising the construction of 335 miles of agricultural roads in the Gharbieh province, the money to be raised by a tax in three years. On account of the higher price to be paid for land, the width acquired was only 19 feet 8 inches, of which the road surface occupied 16 feet 5 inches, at an average height of 1 foot 8 inches above ground level, the remainder being occupied by the slopes, borrow pits being returned to the owners, who, as a

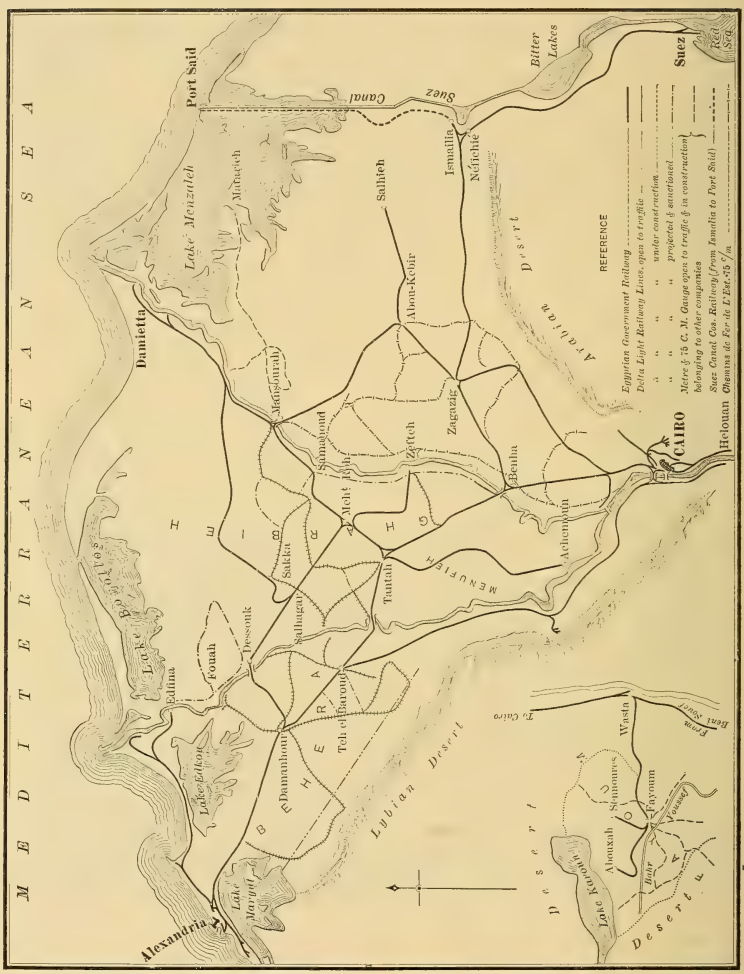
general rule, preferred to have it so. At present there are in the whole of Egypt over 1560 miles of these agricultural roads.

In 1896 the government decided to grant concessions for light railways to be constructed along the agricultural roads, and the firm of Messrs. John Birch & Co., Ltd., of London, were granted a concession for the Behera and Gharbieh provinces, and this concession was afterwards transferred to a company formed in England under the title of the "Egyptian Delta Light Railways," the lines being known in Egypt as "*Chemins de Fer Agricoles.*" The terms of the concession, which is for seventy years, appear equally simple and equitable to both sides. The Egyptian Government guarantees an annual net receipt of £58 per mile, allowing 60 per cent. of the gross receipts for expenses in Egypt, maintenance, working, and administration, including the amortisation of the agreed capital in seventy years. When the gross receipts exceed £360 per mile per annum the government is entitled to 50 per cent. of the excess. The agreed capital figure is £1932 per mile, and the government can purchase the lines, after the expiration of twenty-five years, on one year's notice. From the agreed capital figure will be deducted the amount of the annual amortisation paid to date of purchase, and the purchase price paid by government will be the balance, with an addition of 10 per cent. thereon.

On further examination of the country, it was decided to postpone certain lines, substituting others which traversed a more populous country, and to join up the whole of the lines for facility of working.

A BALLAST TRAIN. CUTTING THROUGH THE SITE OF AN OLD TOWN

The original railways in the Behera, as surveyed, consisted of the following


MEDITERRANEAN SEA
Port Said
Suez Canal
Bitter Lakes
Suez
Red Sea
Lake Menzaleh
Damietta
Matarieh
Ismailia
Nefichie
Salhieh
Abou-Kebir
Desert
Arabian
Matarieh
Zagazig
Zeitch
Simbaoueh
Melt
Ebeihu
CAIRO
Heliouan
Mekhufieh
Tantah
Achemoun
Sakha
Salhieh
Fouah
Tresenik
Edfina
Lake Borollos
Lake Edkou
Lake Maryut
Alexandria
Damanhour
Teh el Barout
Lybian Desert
To Cairo
Wadi
Fayoum
Lake Koroun
Desert
REFERENCE
Egyptian Government Railway
Delta Light Railway Lines, open to traffic
" " " " under construction
" " " " projected & sanctioned
Metre & 75 C. M. Gauge open to traffic & in construction
belonging to other companies
Suez Canal Co.s Railway (from Ismelia to Port Said)
Chemins de Fer de L'Est 75/m

eleven lines, having an aggregate length of 120 miles:—

		Miles.
1.	Damanhour to Delingat	about 16
2.	" " Shibrikhit	" 11
3.	" " Atfeh	" 11
4.	" " Hosh Issa	" 17
5.	" " Chôkah	" 4
6.	Teh-el-Baraud to Shibrikhit	" 11
7.	" " Délingat	" 13
8.	" " Tod	" 8
9.	Kafr-Dawar to Gheta	" 19
10.	Saft-el-Meluk to Messine	" 6
11.	Kafr-Awana to Chandid	" 4
		120

being an essentially agricultural country, and a country of peasant proprietors, and the landowners being averse to disposing of land for any other purpose than agriculture. The peculiarities of land tenure also caused many delays.

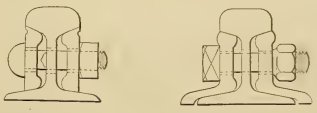
The first point to be settled was the gauge, and it was finally decided by the government that the 75 centimetres (2 feet 5½ inches) gauge should be adopted. This gauge, in the author's

THE WORKSHOPS AT DAMANHOUR

A start was made with the works in October, 1897, materials, rails, sleepers, and fastenings having then come forward; but it was not until April, 1898, that the work was sufficiently advanced to enable a section of sixteen miles in length to be opened to traffic. The lines were opened in the following order:—

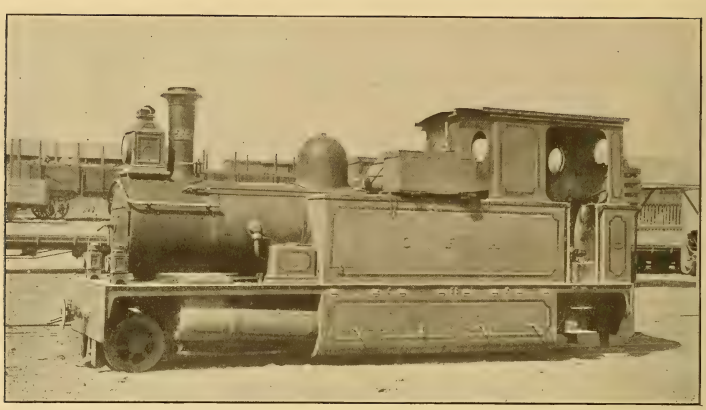
	Miles.
Behera opened to traffic in 1898	88
" " " 1899	59
Gharbieh " " 1899	41
" " " to date	46
Gharbieh and Behera, length under construction and nearly completed	37

The Gharbieh province being in a very backward state in regard to the roads completed, it was only in January, 1899, that a commencement was made. The progress of the lines in this province has not been as fast as might be desired, owing to various causes, but chiefly to the fact that many of the roads had not been completed, and those which were ready were so disconnected that much delay was occasioned by inability to proceed with work once commenced. The question of acquiring land for alterations also presented difficulties, Egypt opinion, was well chosen, the 1-metre gauge being too large and expensive, and the 60-centimetres gauge too small for the volume of traffic and also for the speed required. It was also determined that a thirty pounds per yard Vignoles rail should be adopted, and a sleeper of a minimum size of 4 feet 3 inches by 7½ inches by 3¼ inches, with the option of a spike or a coach-screw for holding down. The spike has been adopted.



RAIL SECTIONS

At first a rail of section *a*, in the diagram on this page, with straight fish-plates, was adopted, and 250 miles have practically been laid with this, but a new section of rail, *b*, having an angle fish-plate, has now been substituted. This will, in the author's

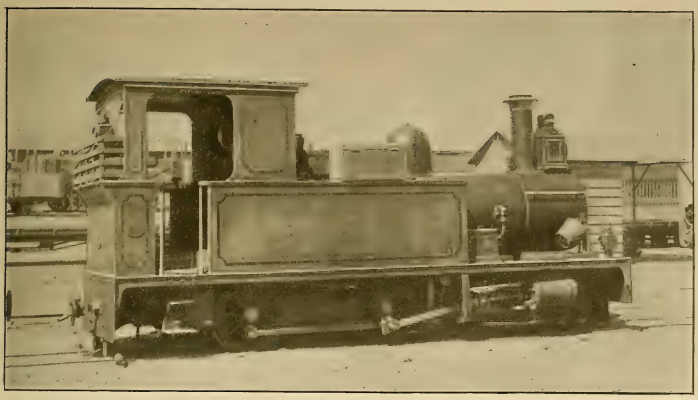


ONE OF THE LOCOMOTIVES WITH DUST SHIELDS

opinion, maintain a better road, especially on sharp curves, and will make a stiffer joint. However, so far no trouble has been given by the old fish-plate, showing that the joint is well proportioned for the weight it has to support. The rails are 30 feet long, and are laid on twelve sleepers, the joint sleepers being 2 feet apart, and the remainder 2 feet 5½ inches apart. This makes a very good road, and gives very little trouble.

The rainfall in the district through which the line runs amounts to from 9 to 12 inches per annum, diminishing greatly after leaving Kafr Zayat, and falling off to a very slight rainfall at Cairo, although during the last two winters Cairo has also had its share of rain. It being impossible during the rains to open out the line for packing where settlement had taken place, there being nothing but the same material to pack with again,—and this was in most cases simply a puddle,—it was decided, after the experience of the first winter, to try ballasting with coarse desert sand. The line, fortunately, ran through a sand-hill at Delingat, and the result has been so successful that there has been no trouble during the winters of 1898-99 and 1899-1900. To keep the sand in place, the line was opened out and lifted to an average height of 4 inches with this ballast, and then boxed up with black earth, and it has been found that in the worst weather in winter a sleeper can be packed. Up to the present about 100 miles have been so treated in the Behera. A connection now having been made with the lines east and west of the main lines, the ballasting of some of the other parts which are low will be done. In the Gharbieh, the rainfall being less, there is not the same necessity for ballasting; but even in that province there are portions of the line which would be greatly improved if they could be so ballasted; unfortunately, from the engineering point of view, however, there is no sand, the whole of the province so far covered by the railways being black cotton soil or alluvial deposits from the canals. Another point which has been noticed is that the line keeps its alignment much better when on the sand than on the black earth alone.

As to curves, according to the terms of the concession, a minimum radius of 2 chains on main line and 1¼ chain in stations was allowed, the rolling stock having a fixed wheel-base of 6 feet 6 inches, and the engines a rigid wheel-base of 5 feet. Although it is quite possible to run round even a 1-chain curve, it has been found advisable to observe a



THE SAME STYLE OF LOCOMOTIVE WITHOUT DUST SHIELDS

minimum radius of 3½ chains on the main lines, and this only in exceptional cases. In general, 5 chains are the radius fixed, some of these curves working round a fourth part of a circle. By having a flatter curve it is unnecessary to reduce the running speed on any portion of the line, and a saving in wear and tear of stock and in maintenance of the line is effected. In the author's opinion, it is advisable to keep the curves on main line as flat as possible, and it is well worth the extra cost of taking up small portions of land to do this.

As to gradients, the delta being absolutely flat, this question is easily dealt with. The longest incline is about 30 chains in length, and the steepest gradient is 1 in 100, the usual rise over a canal being 1 in 200. The bridges vary between 2 metres (6 feet 7 inches) and 10 metres (32 feet 10 inches) span for fixed bridges. Swing-bridges, on central piers of 5-inch solid screw-piles, are in use over navigable canals. Eight of these have already been sent out, and several more will eventually be used over canals of various widths. The swing portions are all of the same span. These swing-bridges are in every way satisfactory, and can be opened by one man easily.

The bridgework has been supplied by various makers in the United Kingdom, and a number of the small sizes, up to 4 metres (13 feet 1½ inch) span, have been made in the company's workshops at Damanhour from rolled joists bought locally. On account of the line following the agricultural roads, it was found impossible to adopt a single type, especially as it was necessary to cross canals at all angles (the irrigation officers generally objecting to any deviation of canals). The girders are considerably heavier than would be generally required for such a light line, but this is due to the fact that the Egyptian Public Works Department practically insists on a maximum stress of 4.12 tons per square inch for iron, and even for steel, in bridges up to 50 metres span. Besides this, they insist that any combined road and railway bridge shall be so made as to support, besides the rolling load, a crowd of people, and also a sixteen-ton portable or traction engine.

Besides the bridges over canals and drainage channels, the whole of the country is intersected by minor irrigation and drainage canals, for which openings have to be provided; these vary between culverts of about 5 feet in width and earthenware or iron pipes of about 3 feet to 10 inches in diameter. Many of these existing have had to be re-

AN INSPECTION TRAIN

placed, and, in general, earthenware pipes having less than 10 inches of cover have been replaced by cast-iron pipes, those having more than this being replaced either by earthenware or cast-iron pipes, as circumstances necessitate. The smaller pipes, of 8 inches and 6 inches diameter, if in good condition and of good quality of earthenware, are left in, but in all cases light heads of masonry are built up on the line side to prevent scour. "Beton Armé" pipes have lately been tried by the government for this work, but, in the author's opinion, these are not satisfactory.

The locomotives for both passenger and goods service are of a uniform type, with four wheels coupled, side tanks, a four-wheeled bogie in front, and weighing in working order about fifteen tons. The dimensions of these are the following:—

Diameter of cylinder	9½ inches.
Stroke	14 inches.
Diameter of coupled wheels	2 feet 6 inches.
Rigid wheel-base	5 feet.
Diameter of bogie wheels	1 foot 6 inches.
Centre of trailing driving-wheel to centre of bogie	11 feet 6 inches.
Centres of bogie wheels	4 feet.
Heating surface, fire-box	30 square feet.
Heating surface, tubes	224 square feet.
Grate area	5 square feet.

Pressure 140 lbs. per square inch.

The first ten engines, as supplied, were fitted with link motions inside, but on account of the narrowness of the gauge it has been found advisable to do away with the eccentrics, it being practically impossible to get under the locomotives except from a pit, and consequently the oiling of these parts of the machinery was often unsatisfactory. The engines are now being fitted with the Baguley outside gear, which, up to the present, has given entire satisfaction, and the engines so fitted are much preferred by the men. On account of the small diameter of the wheels the whole of the machinery is pitched very low, and much trouble and extra expense has been incurred in repairs to the locomotives, necessitated by dust and grit getting into the bearings and grinding them away. The covering-in of the motions by casings, which is now being tried, will, it is hoped, do away with this to some extent; but it is too early yet to say what the results will be, although, taking the short time the engines so encased have been at work, it seems likely to be well worth the slight extra expense.

The following maximum axle-loads were approved, viz., engines, six tons; carriages and waggons, four tons. The rolling stock, waggons and carriages, has a fixed wheel-base of 6 feet 6 inches. The four-wheeled stock, having a carrying capacity of five tons, weighs a little over two tons. The stock, as far as the goods traffic is concerned, has been found quite satisfactory for the work for which it has been designed. Experience in the last two cotton seasons has shown that a net load of four and one-half tons of unpressed cotton, with seed, can be carried on the open platform waggons, or a full load of five tons of grain and heavy goods, the high-sided waggons

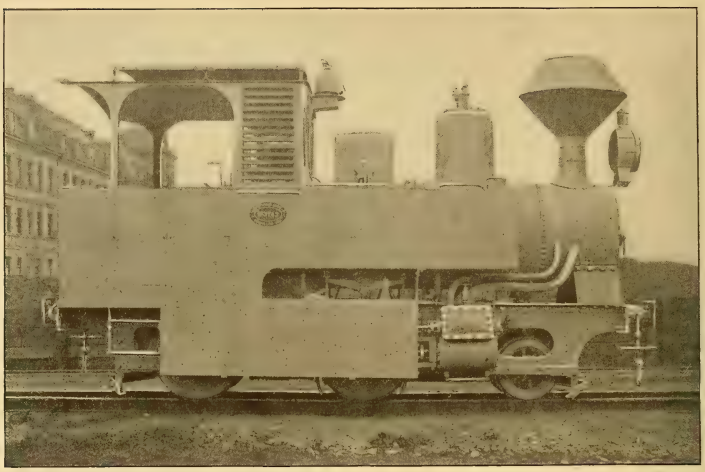
carrying easily four tons of Newcastle coal, and at a push five tons of Welsh coal. The tare of these open waggons is a little over two tons. The stock being low,—2 feet from ground-level,—it has not been found necessary to provide platforms, and the trucks are easily loaded. A small number of ten-ton bogie platform-waggons have also been provided for the special purpose of carrying long timber and heavy articles; these are 28 feet in length, and have a tare of four and one-half tons.

The coaching stock is of two classes,—first and third. The original first-class carriages had one *coupé* compartment, having carrying capacity for twelve passengers. Only ten coaches of this type were supplied. The concession required that a special ladies' compartment must be provided. The remainder of the stock supplied consists of two cross compartments, each compartment holding eight persons. The original third-class carriages had cross benches and open sides, but on account of the rains a number of closed carriages have now been provided, the bodies being built in Egypt. Road vans, brake vans, and cattle waggons are also provided. Besides the foregoing, two saloon carriages on bogies have been provided for the use of His Highness the Khedive,—one for use in each province. The wheels, axles, axle-boxes, and brasses in use on the bogie stock are similar to those on the four-wheeled stock. The whole of the four-wheeled stock is uniform in regard to wheels, springs, axle-boxes and brasses, buffers and under-frames, thus reducing the number of parts to be kept in stock, as well as facilitating repairs by being interchangeable. The engines were built by Messrs. W. G. Bagnalls, Ltd., of Stafford, and the other stock by the Oldbury Railway, Carriage and Waggon Company, of Birmingham.

In general, only one siding is provided at stations, crossing stations having, in addition, a lay-by for trucks. Ordinary stations have, in some cases, through sidings, and in others a dead end only; the latter are principally used in the cotton season. Damanhour is the principal centre of the Behera system; the lines are all connected there, and a specially large station yard has been found necessary. The workshops, stores and offices are also situated at this place. The ordinary side stations vary slightly in length, according to the land taken up, but are generally either 740 feet or 500 feet in length.

A TRAIN OF OPEN THIRD-CLASS CARRIAGES

The station buildings are for the present only temporary, and are usually formed of one or more wooden huts, 12 feet in length, with an open roof joining the two when two huts are found necessary. To enable these to be easily removed they are made in segments, each 6 feet in width and 8 feet in length, bolted together, and are covered with corrugated iron. It has since been de-



ONE OF THE LOCOMOTIVES ON THE CHEMIN DE FER DE L'EST

cided to erect permanent buildings at several of the stations where a fair amount of traffic is handled. At other stations the temporary arrangements will be in use until the traffic develops. By having only temporary buildings at the commencement, it is very easy to close stations where the traffic results prove that they are not necessary.

Watering stations are provided with a small tank measuring 8 feet by 4 feet by 4 feet, having a frame pump fixed on a trestle. In some places a trial has been made with water taken from wells, but this is now being abandoned, as the water is invariably brackish and causes priming. In the majority of cases the tanks are fixed near a small canal; this, being Nile water, is sweet, and, although rather discoloured and heavily charged with silt at certain times of the year, there is little or no hard deposit. Examination of a number of old boilers in the country showed little or no corrosion, and the deposit washes out freely. In all cases, where possible, the pumping is done by the pointsman where tanks are fixed at stations.

A telegraph line has been tried on a length of thirty miles, but for the present it is not intended to carry it farther, unless traffic develops to a greater extent. Trains are run to a regular time-table, and are worked on a "train staff and ticket system;" this being simple, the train and station staff have taken to it readily, and thoroughly understand it. The following is a statement of the goods and passenger traffic for the six months ended March, 1900. This traffic was readily moved, and double the amount could have been dealt with.

Number of passengers carried	545,400
Average distance travelled per passenger—	
First-class	9½ miles
Third-class	8½ miles
Goods carried—	Tons.
Building material	4,200
Coal	4,600
Cotton	23,400
Cotton seed	2,100
Grains (various)	4,800
Manure	9,400
Natron	2,600
Timber	2,500
Straw chopped, fodder	1,200
Miscellaneous goods	7,200
Total	62,000

The average distance over which goods were carried was thirteen and one-quarter miles, and the total distance covered by public traffic, goods and passenger, was 174,000 train-miles.

The system adopted in carrying out

the works has been to distribute earthworks and masonry among a number of small contractors, the company's staff setting out the lines and supervising the work. The linking, lifting, and ballasting being done by the company's labourers, the work has been done more satisfactorily than by contract, besides having the advantage of training maintenance gangs. On the commencement of the works, there being very few platelayers in the country, those engaged on the government lines not caring to leave and enter a private company, it was ound advisable to import a small number of experienced men; these were brought over from Asia Minor. Two permanent-way inspectors and six gangers were first introduced, a few others following later, and they were each given a gang of natives to instruct in the work as it progressed. Small gangs of the most intelligent were picked out and left in charge of the maintenance, and each forty or fifty miles were in charge of one of the old gangers, who was called a sub-inspector.

At the commencement it was rather difficult to get sufficient men, but now the supply exceeds the demand, the men seeing that there is regular employment and a slightly better pay than is usually given to the farm labourers. The same procedure was followed in the case of drivers and mechanics; these are now being trained in the company's own workshops, and no more difficulty is anticipated in regard to the supply. Those trained by the company, as a rule, take a greater interest in their work than others picked up casually. Some trouble and delay were encountered at first through the inexperience of some of the drivers, but the men are now gradually improving, and are feeling more confident. The longest day's run for an engine and crew is about 100 miles, taking a day of fourteen hours, and including two stops of two hours and one and one-half hour. The engines work three days consecutively, with one day in shed. The washing-out is done by the engine crew, who also do their own gland packing under the supervision of the head fitter. Practically the whole of the traffic staff, such as station masters, guards, shunters, etc., are natives, and have been trained by the company, and, as a rule, the work done by them is very satisfactory. The whole of the traffic accounts are kept in English.

The passenger and goods traffic are very nearly equal, although it was thought at the commencement that the goods traffic would be the more remunerative. The traffic figures show that the public appreciate the lines, and as they gradually do away with the horses, mules, asses and camels, the lines will benefit much more in the near future. The average speed of passenger trains, including stops, is about sixteen miles an hour.

The original estimates for these lines amounted to £1325 per mile for works only, and £1500 per mile with cost of cover, flotation and preliminary expenses. These figures were at first closely adhered to, but the increasing cost of materials, the need for bridging the larger canals, and the increase of rolling stock required to meet the traffic may eventually increase this and bring the cost to about £2100 per mile. Judging by present receipts, the lines evidently meet the wants of the agricultural class, and seem likely to pay very well. The company has recently acquired the system of the Chemin de Fer de l'Est on the same gauge, and expect to be conceded lines in the province of Menufieh. They will then have practically the whole of the delta under one system of feeder railways.

That such a large system will assist materially in developing the country districts in which communication was difficult a few years ago is quite certain, and after completion of the whole of the present scheme of irrigation and drainage works now being carried out by the government, of which the Assouan-Assiout dams in Upper Egypt, as well as a smaller one at Zefteh, in Lower Egypt, form part, there is no doubt that cultivation in Lower Egypt in most of the districts served by these light railways will increase to a still further extent. From this the railways will greatly benefit.

It is still too early to give statistics of

operation, considering that the majority of the lines have only just been joined up with the necessary over and under bridges crossing of the trunk lines. The working expenses of the combined system for the six months ending September, 1901, amounted to 70 per cent. of the gross earnings, and considering that this was the slack season during which a large volume of low-rate goods was carried, the figures may be considered fairly satisfactory, especially taking into consideration the high price of coal, which averages 33s., 1d., per ton delivered in stores.

The estimated working expenses for the twelve months ended January 1, 1902, are 60 per cent. of the gross earnings. The volume of traffic for the six months ended September, 1901, was as below, and forms an interesting statement when compared with the figures already given for an earlier period.

Number of passengers carried	1,493,000
Average distance travelled per passenger—	
First-class	9 miles
Third-class	8 miles
Goods carried—	Tons.
Building material	90,000
Coal	10,000
Cotton	14,000
Cotton seed	1,300
Grains (various)	15,000
Manure	50,000
Timber	6,000
Straw chopped, fodder	6,000
Miscellaneous goods	12,000

The total distance covered by public traffic, goods and passenger, was 480,000 train-miles. It will be noted that the greater quantity of the goods traffic was building material and manure, both these items having been carried at exceptionally low rates.

Of building material, 81,000 tons were stone, carried to the new dam now being constructed at Zefteh, the balance being building material for use in the different towns served by the lines. Manure figures again for a very large quantity; this will naturally return back later on in revenue in other forms.

The results of the working of these narrow-gauge railways show that many places may be suitably served by a railway, safe, speedy, and comfortable, at a cost of less than £2000 per mile.

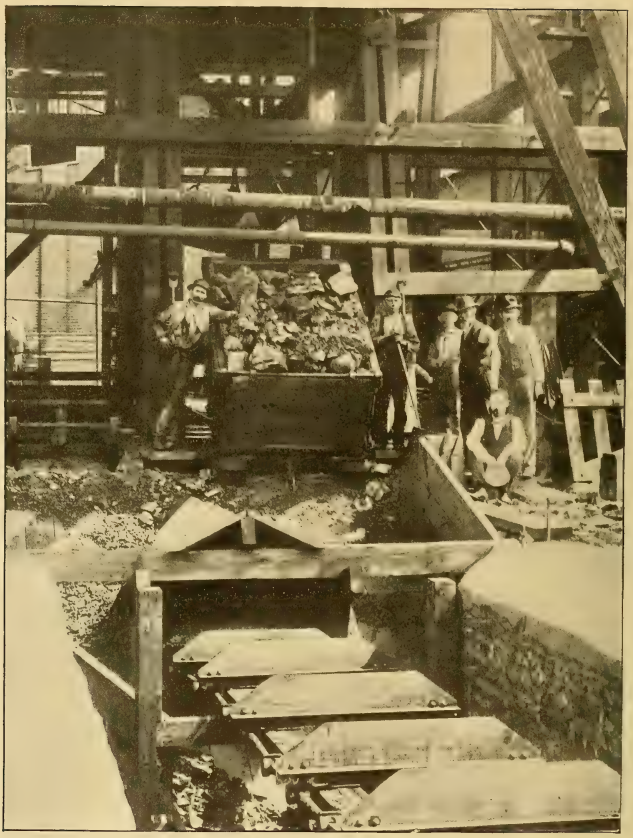
The author has been in charge almost from the first as chief engineer. The consulting engineers have been until lately Sir B. Baker, K. C. M. G., and Mr. Horace Bell, MM. Inst. C. E. The latter is now acting alone in this capacity.

THE TRAMWAY AND LARRY AS CONVEYORS

CONVEYING MACHINERY IN COAL MINING

By S. Howard-Smith, A. M., M. Am. Soc. M. E.

THE value of a material is a composite of inherent quality and superposed labour. The first element being constant, final value depends wholly upon labour cost, and is increased by every reduction of this component. Mining product is subject to costs of processing and of moving. With the former this paper is not concerned, and it will be found convenient to treat moving under the two heads of transport, for which cars or vessels are



AT THE HEAD OF A SHAFT

employed, and conveying, which is tributary to both transportation and processing, and is accomplished by machines permanently fixed in their several locations. It is the writer's intention to show the extent to which conveying machinery has been found profitable in handling a mineral product, and as the most extended and systematic use of conveyors is now made in the anthracite coal regions of Pennsylvania, this sketch will be confined to the mechanical treatment of the coal there between mine and market.

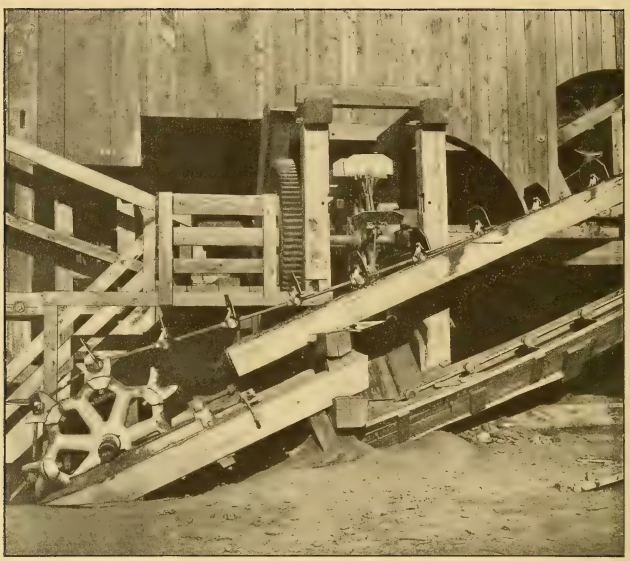
The hard or anthracite coal measures of Pennsylvania underlie the districts immediately south of the Blue Ridge and those lying between the Broad and Allegheny mountains. In these, known as the Wyoming, the Lehigh and the Schuylkill districts, nearly fifty million tons of coal were mined during the last year. When it is realised that the saving of a single cent, or half-penny, per

ton in the labour cost of handling this output amounts to $500,000 (£100,000) per year, full reason is found for liberal investment in machinery to increase the speed and cheapen the cost of carriage and processing.

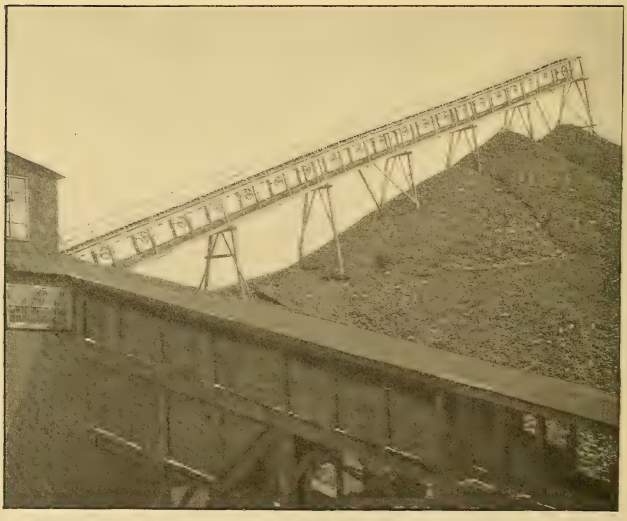
The conditions of actual mining do not permit advantageous use of fixed conveyors. The steadily lengthening and diverging lines along which the vein is followed and along which the mine product must return to the shaft, and the requirement that each miner's output be separately delivered for tally and inspection, make the problem one of transport rather than of conveying, and forbid departure from the tramway and larry in general use between workings and shaft; but on arrival at the surface, the larries, or mine cars, are emptied in quick succession into a conveyor running to the head of the breaker. This conveyor, as a link in the coal-handling system, is of comparatively recent adoption, but is gradually replacing the rope hauls by which the cars themselves were taken to the breaker head, as it requires a less expensive supporting structure, gives more even delivery to the crushing rolls, and is less liable to expensive accidents.

This conveyor,—from 250 to 300 feet in length,—is the throat connecting the mouth of the mine with the digestive machinery of the breaker. As its capacity must be equal to the output, it is the largest employed in coal handling, having to convey up to 3000 tons per day. Strength and durability are essential, since the operation of the breaker is dependent on this machine. It consists of a double line of 1½-inch or 1¾-inch iron bolts, 2 feet long, with malleable iron connections to which steel scrapers, 4 or 5 feet long, are attached, forming a flighted chain, which, actuated by sprocket wheels and gearing, pushes the coal along a steel trough, and delivers it in a practically uninterrupted stream to the crushing

A MAIN CONVEYOR FROM MINE SHAFT TO HEAD OF BREAKER



CULM CONVEYOR CARRYING SCREENINGS FROM A BREAKER



PILING UP A SLATE AND CULM HEAP

rolls in the breaker head. The passage of coal through the breaker in which it is sized and separated from adhering slate is by gravity, but as there are practical limits to the height of the structure, conveyors and elevators are employed to return slaty or bony coal for recrushing and sizing, the number and arrangement varying with the design of the breaker, and being greatest in wet breakers where jigging is an essential part of the preparation.

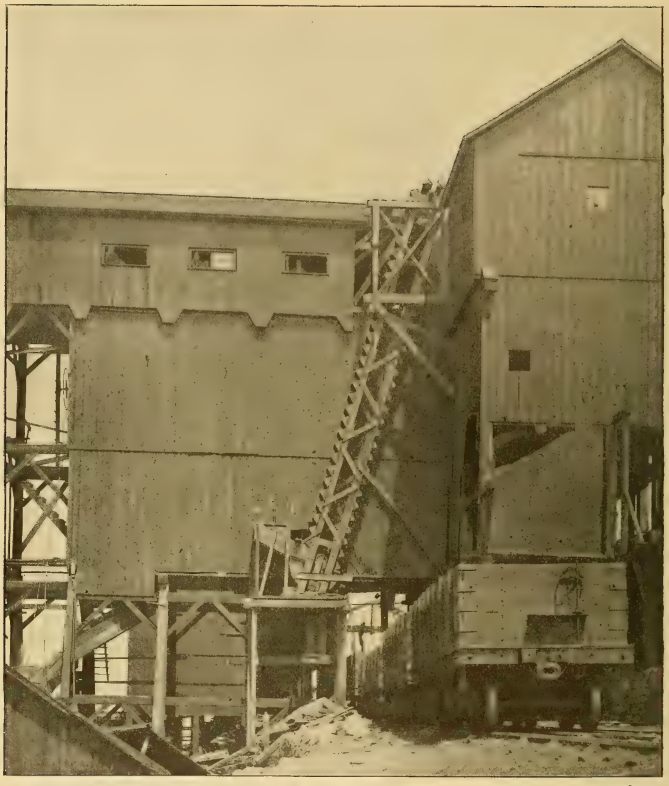
has figured liberally in the records of litigation through the Wyoming and Schuylkill valleys in Pennsylvania.

Until within the last few years the coal deposited on them has been considered irreclaimable except at prohibitory cost, but as improved combustion methods have given value to even the smallest sizes, a number of washeries have been established in the region in which the so-called steam sizes are separated from the refuse of the culm

A TYPICAL WASHERY

Conveyors also run under the breaker to collect the dust and refuse, which are carried out on the culm bank by another conveyor usually at right angles with the breaker lines. These culm banks form the most conspicuous feature of the coal regions. If they cannot be called mountains, they are at least respectable foothills, and their building

banks, and which require a separate system of conveyors between bank and washery. This system usually consists of a swinging or pivoted conveyor, lying along the base of the bank, and adapted to follow it up as the reclaiming proceeds; an inclined conveyor leading into the washery; and an intermediate conveyor connecting the two.



BONY COAL ELEVATORS

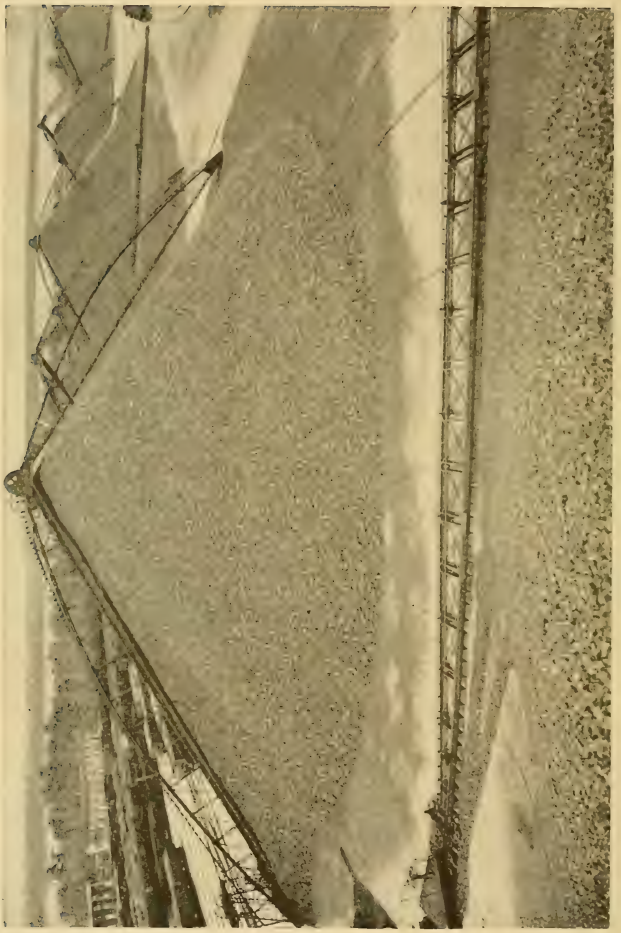
Another use to which these vast piles of waste material are put is the filling-in of abandoned workings, which, if left empty and unsupported by the columns of coal which carry the overhead weight while they are active, would settle, and thus seriously affect the value and safety of the overlying land. At some mines this refilling is effected by a system of conveyors or scraper lines similar to those between culm bank and washery, the swinging or pivoted conveyor following up the receding edge of the bank and delivering the culm to a fixed conveyor which terminates at the "bore hole" leading vertically down into the abandoned chambers.

From this incidental mention of the reclaiming system we return to the breaker and find the marketable coal being delivered to cars through chutes at the foot of the breaker and started on its transport to tidewater, or to the intermediate storage plant, which, during the past decade, has supplanted the use of the cars themselves for storing inactive sizes, and serves as an equaliser between mine and market. These plants are located on the line of the carrying road, either at tidewater, or in

THE RELOADER OF A STORAGE PLANT

the vicinity of the mine, or at an intermediate point from which one or more round trips can be made in a day. The storage capacity ranges from 100,000 to 300,000 tons, in conical piles of 10,000 to 50,000 tons each, formed upon the levelled ground. Each pile is spanned by the supporting structure of a flighted conveyor, which, starting beneath a track hopper into which the cars are dumped, carries the coal up at its natural angle of repose,—about 27 degrees,—delivering it always at the summit of the growing pile without fall or breakage. Between each two piles so formed, a conveyor, pivoted at its end nearest the reloading track and supported by circular tracks laid flush with the ground, is operated to attack the base of either pile and sweep the coal back to an inclined conveyor, which, in turn, delivers to cars for transport to terminus of road. The entire labour cost of storing and reloading does not exceed 5 cents (2½d.) per ton, and the coal is handled, without sensible breakage, at a rate varying from three to six tons per minute.

Consideration of conveying machinery, as related to mining operations,



A STORAGE PLANT. THE CONICAL HEAPS OF COAL CONTAIN FROM 10,000 TO 50,000 TONS

might logically end with delivery of the coal to the storage plant, if not to the railway cars at the breaker, and it is not within the scope of this article to minutely describe the storage system, or to follow the coal through the conveyors and elevators which it encounters in its further travel through the retail yards, or the power house, till finally, by a telescopic elevator which comes up through the city sidewalk, its ash is deposited in the waiting dump cart; but in view of the fact that, fifteen years ago, coal conveyors were practically unknown, while to-day the conveyor equipment of a breaker costs as much as $25,000 (£5000), and that storage plants costing upward of $200,000 (£40,000) are found profitable investments by the carrying roads, it will be of interest to note three elemental inventions which have made possible the present efficiency of coal handling machinery. The writer refers to the well-known detachable, malleable iron chain first generally used and which still holds its place for short hauls and moderate capacities, the cable chain with interposed bearing blocks which followed and for years met the demand for long-distance conveying and the heavy work of the storage plant, and the chain of connected bolts, with its still greater strength and increased wearing surface, which is the standard of to-day.

Many other inventions have done their part in the saving of labour, reduction of installation cost, and increase of durability; but the efficiency of the conveying systems and the practical value of all other inventions connected with the conveying of material is directly dependent upon the chains, and it is to the ingenuity which has devised and the skill and care employed in the manufacture of these that the highly developed system of handling anthracite coal between mine and market is due.

ELECTRIC POWER IN AMERICAN COTTON MILLS

By W. B. Smith Whaley

COTTON spinning in the South of the United States had its origin in either North or South Carolina. In the early thirties cotton spinning machinery was installed either at Lincolnton, N. C., or at Batesville, S. C., both places having meritorious claims as the pioneer location of the industry. These early mills were located on small streams with less than fifty horse-power, with the overshot or undershot wheel customary in those days, made by the aid of local millwrights and blacksmiths, and were of a crude pattern and low efficiency.

Examples of the intermediate mills are not easily obtained. The machinery was, in many instances, imported from England, and could be had only at large expense. The Graniteville Manufacturing Company was organised in 1856, and erected a factory which represents the oldest existing type of mill in the South, equalling any mill of its day in New England. The mills which followed the one at Graniteville were located on water powers, then considered the only available means of operating factories, and afford little of interest or instruction.

Steam for operating cotton factories was utilised as early as the sixties. The building now used as the almshouse in the city of Charleston, S. C., was constructed and equipped as a cotton mill, but was not a success, its failure being attributed to its steam power. The factory was dismantled and the machinery sold to a company in Georgia, to which State it was moved and where it operated satisfactorily in a water-driven mill.

The present substantial growth and expansion of the American cotton mill industry in the South began about 1880. Large manufacturing centres were established in the Piedmont district of South Carolina, followed by the development at Augusta and Columbus, in Georgia, and other prominent water power points. The larger portion of the mills were de-

394 THE HYDRAULIC PLANT OF THE PELZER MILL

A WATER-POWER ELECTRIC COTTON MILL AT PELZER, SOUTH CAROLINA

A VIEW OF THE CARDING ROOM

signed by expert engineers of New England, and equipped with imported machinery of British make. The success of these institutions led to the establishment of many others, which placed water power in great demand, as that was still considered the best power for cotton factories. The majority of the stock in these mills was owned in the South.

The number of mills steadily increased, the returns were most satisfactory, and the readily accumulated surplus was converted into more spindles and looms. The type of mill was of the standard 8-foot bay and low-story construction of the period, found North and South, built of brick and roofed with tin. In many instances second-hand machinery was brought from Northern mills and used to good advantage, owing to the cheap labour, cheap living, and long hours prevailing. The class

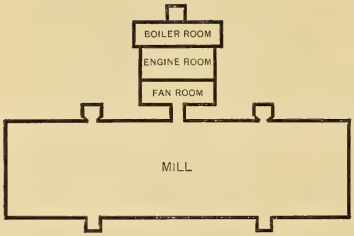


FIG. 1.—OLYMPIA MILLS

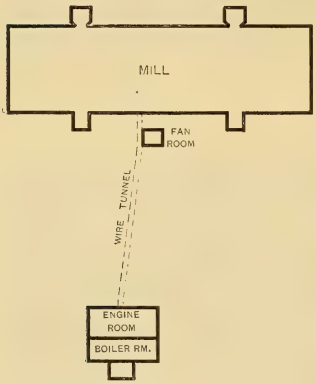


FIG. 2.—THE BUFFALO MILLS

FIG. 3.—THE DE KALB MILLS

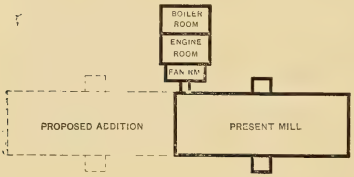


FIG. 4.—THE INMAN MILLS

of goods manufactured was coarse sheeting for the export trade, as well as for the local country trade.

From 1890 to the present time the increase of the industry throughout the South has been phenomenal. The buildings are modern, and the very best British and American machinery has been installed in mills holding as large an equipment as thirty and forty thousand spindles, whereas formerly a ten-thousand spindle mill was considered a very large enterprise. The adoption of improved methods of manufacturing was rapid, until at present there is no section of the world with better operatives or finer equipped plants.

Steam almost entirely succeeded water as a source of power; ropes and belts supplanted cogs and gearings, and have, in turn, been superseded by electricity. This brings us to the present stage of the industry in the South, which is now converting cotton into a variety of goods on as large a scale as any other portion of the United States, not excepting New England, which has long led in cotton manufacturing.

To the engineer, the chief interest in these Southern cotton mills is afforded by the fact that pre-eminently the South is the section in which the electric drive is being used to a larger extent than any other. This is due chiefly to the fact that the proportion of new mills is larger there than elsewhere, and each builder wishes to erect a highly modern plant, while an established mill is slow to change its source of power. The electric drive is certain to effect important changes in mill construction, and has already done so very largely. It will, therefore, be profitable to consider the Southern cotton mills which illustrate the advantages claimed for electricity in cotton mills.

In the early development the employment of electricity was spasmodic and mainly confined to the conveying of power to points difficult of access, for which it was found better adapted than any other method of transmitting power, despite the increased cost of installing the machinery. From this small beginning electric power has assumed, as we

THE OLYMPIA MILLS, COLUMBIA S. C. THE LARGEST AND LATEST TYPE OF ELECTRICALLY DRIVEN COTTON MILL IN THE UNITED STATES

will see, large proportions, and it is safe to say that it has established itself so permanently in cotton manufacturing that in the future its utilisation will be the rule and not the exception.

The Ponema Mills, at Taftville, Conn., were among the first to employ electricity for the convenient transmission of power, being enabled by it to carry power from one of their mills, which had a surplus, to another which required a larger amount of power than the plant installed in it could develop. Both plants used water power. Following on the heels of this progressive experiment came the notable installation, at the Columbia Duck Mills, at Columbia, S. C., in 1894, of the electric drive. The motive there was not that it was more economical than the usual methods of transmission then in use, but the peculiar conditions existing, for the mill had to be located on the inner bank of the canal furnishing the power, instead of between the canal and the river, where the power plant was located. It was in this case found more convenient to install the electric drive than to convey the power by ropes across the canal in such a fashion as to permit the passage of boats. Consequently, the electric method of driving the mill was accepted, and this led to the application of the electric drive in its true sense as a method of operating the factory, rather than as an adjunct or side issue to supplement other means of operating.

The problems were carefully worked out, and the power plant has been completely successful. The questions there presented were carefully investigated by

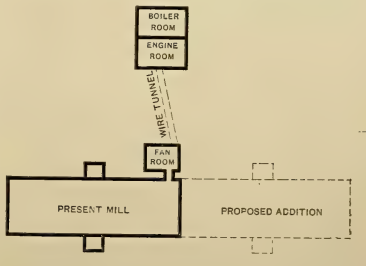
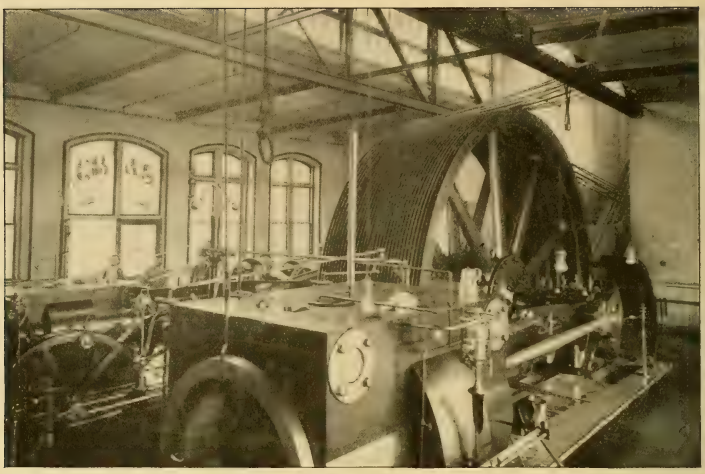


FIG 5 —THE SENECA MILLS



A COTTON MILL ENGINE ROOM OF THE OLD TYPE, WITH ROPE DRIVE

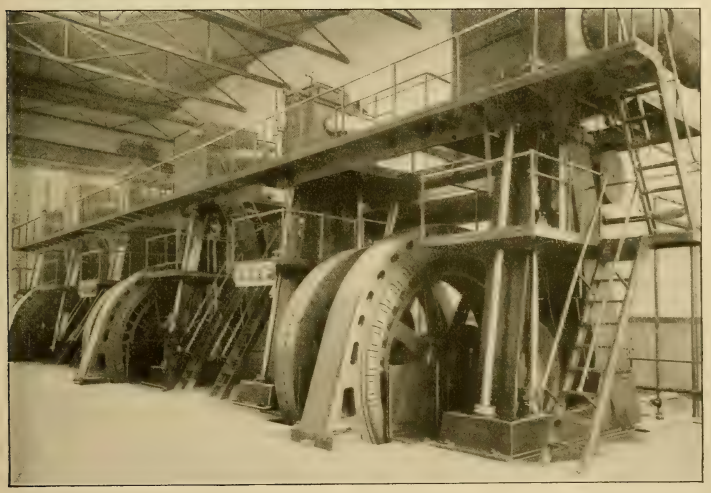
all those interested in textile factories, with the result that, from the valuable data obtained, a series of evolutions followed that have culminated to-day in the economical application of electrical power for textile purposes. And there are installed and are being installed no less than twenty plants of over 40,000 horse-power, all driven by electricity.

The first mills adopting this method of transmitting the power from the prime mover to the manipulation of the mill considered it feasible only where water mills were established, and on account of the fact that the location of the mill itself could be more conveniently arranged where it was not incumbent upon the engineers to place it at the water power. These views have been gradually changed through the improvements that have sprung up from the vast amount of information obtained from the pioneer plants, so that it became practical and advisable, from the standpoint of first cost, as well as manipulation, to apply the generator to the steam-engine also, and operate the mill electrically instead of by means of ropes or belts. With this latter phase of the development the writer has had the privilege of being peculiarly and largely identified.

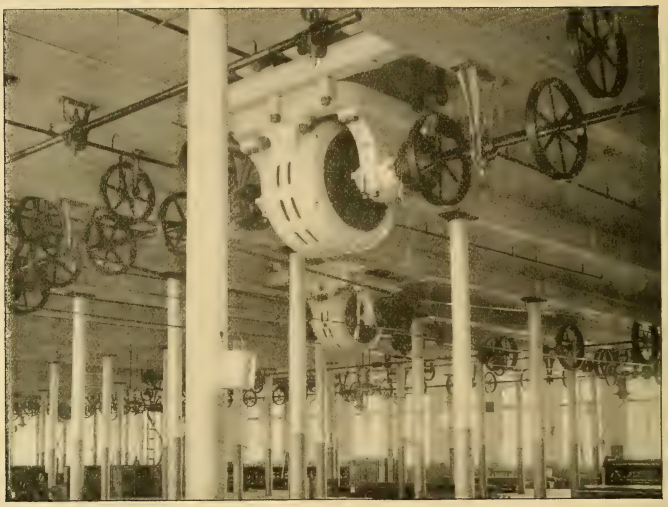
The advantages presenting themselves were the following:—1, Less costly and more conveniently arranged buildings; 2, immunity from interruptions due to the necessity of shutting down the whole plant on account of any section being out of order; 3, more economical steam plants, both in first cost and in operation; 4, a very large saving in shafting and belting; and 5, the absolute unimportance of the relative position of the power plant and the mill. Starting with this last proposition are shown Figs. 1 to 5, illustrating several steam-electric-driven mills actually constructed and in operation, and embodying various plans for locating the power plant. In each case the locations were determined by the most economical position of power plant, to enable it to obtain water for steam and condensing purposes, and of the mill for the most convenient situation for the railways and to find inexpensive foundations. In Fig. 1, representing the Olympia Cotton Mills, at Columbia, S. C., there are installed 6000 horse-power in three units, giving the advantage of not only much lighter

machinery in the power plant, but a far more flexible plant, on account of the rare probability of the three units being out of repair at the same time. Fig. 2 illustrates the Buffalo Cotton Mills, at Union, S. C., where the mill is situated practically at the top of the hill and the power plant 300 feet in front, at the foot of the hill, to gain access to water for steam purposes and convenient railroad facilities. Fig. 3 shows the De Kalb Cotton Mills, at Camden S. C., with the power plant at the end of the mill instead of in the rear, for the reasons last stated, and also to permit an enlargement, with no further addition to the power plant, except the installation of the necessary units of engines, generators, and boilers. Figs. 4 and 5 are, respectively, the Inman and Seneca mills, at Inman and Seneca, S. C., which illustrate the same advantages. These show the extreme adaptability of the electric drive more forcibly than any other method. The illustration opposite shows the method previously followed in driving a mill by means of ropes, or belts, in a rope-way, and which made it necessary for the engines to be located in the rear of the mills with heavy transverse walls for the rope-way. This plan permitted no flexibility, and necessitated the shutting down of the whole plant in case of any accident to a part.

The convenience of distributing power in any direction by means of electric wires must appeal to those interested in the transmission of power, to say nothing of the absence in the sub-divisions of the mill itself of friction clutches and other devices for disconnecting continuous lines of shafting. The absence of weight in transmission, due to belts, or ropes, heavy receiving pulleys, large shafting, expensive head gearing, etc., is an advantage, as well as the decreased first cost, and the subsequent decreased power consumption due to the lessening of friction. The absence of dirt, dust, lint, and other flyings that are continually brought to the bearings of the engines and which often cause heating; the assurance that incompetent employees cannot put undue strains on the transmitting shafts by injudicious



THE NEW TYPE, WITH ELECTRIC GENERATORS



THE ELECTRIC MOTORS ARE OVERHEAD, OCCUPYING NO FLOOR SPACE

tightening of belts or ropes; and the entire absence of hygrometry on ropes and belts, which produce similar results, are factors of considerable saving in power. The transmitting wires have no moving weight, and consequently entail none of these detriments. There is no change in them except electric losses, and no necessity for belt way, belt guards, or safety devices.

The motors, which are placed overhead, as shown above, do not occupy any floor space, are absolutely out of reach, afford no danger to human life, and are so proportioned as to give, according to the number installed, the greatest flexibility to the plant as a whole. No special machinery is installed for lighting the plant, as the current is taken from the generator producing the power. Temporary power for any purpose, in any portion of the plant, is easily supplied by a portable motor, which is readily tapped on any power circuit in convenient reach. These and many other advantages, from a mechanical standpoint, have been demonstrated by actual experience.

There is a saving in the friction alone of 20 per cent. The producing capacity of the machinery operated is, in actual practice, increased about 4 per cent., due to the steadiness of this method of driving over the usual method of ropes and belts, and the more uniform speed obtained throughout the plant. The enormous flexibility and economic problems solved by the installation of these electric-driven cotton mills are felt even outside of the mill itself. The plants are readily available for furnishing power to others within reach to the extent of its surplus, and may produce a considerable revenue from this source; and they can supply power at a lower figure than that at which isolated plants could generate their own power.

In the city of Columbia, S. C., the Olympia power plant not only drives the Olympia Cotton Mills, the Granby Cotton Mills, and the Capital City Mills, but also the street railway, and furnishes the light and power company current for cars, arc lights and incandescent lights from the same source, and more economically than the individual companies

could maintain separate power plants, while the Olympia Mills sell the current at a substantial profit.

South Carolina will shortly have operating no less than fifteen of these electrically-driven cotton mills, which will gradually affect the economic conditions in the section surrounding each of them, by offering conveniences more cheaply than these communities could possibly hope to get them by independent plants.

It appears possible thus in the near future to operate a line of electric railroad, with mills and intermediate power stations, from the mountains to the sea, and at less cost than by the establishment of plants for the purposes of the roads alone.

The direct electric drive is no longer an experiment, and there is no more exacting work than textile factories, on account of the demand at all times for the maximum of power.

A POSSIBLE SOLUTION OF THE LABOUR PROBLEM

BY AN AMERICAN WORKS MANAGER AND PROPRIETOR

W. D. Forbes

IT is not for a moment supposed by the writer that this article will cause a revolution in thought or action in the labour or moneyed worlds, but he believes that it suggests ideas which, at least as far as he knows, have never been offered before, and may be worthy of a passing thought by those interested in the so-called labour question.

Prejudice and intolerance on both sides are the main causes of friction between unions and those who employ any kind of labour. It seems to the writer unfortunate in the extreme that at the Industrial Peace Conference held at New York a short time ago, of which the Hon. Oscar S. Straus wrote in the February number of this magazine, and which was avowedly brought about to have Capital and Labour better understand each other and each other's work, with "get together" as its motto, two of the most noted gentlemen there should have represented religious elements. In Archbishop Ireland was represented a great organisation, which, on the question of religious worship, holds that there is but one way of doing this to gain eternal life; the other noted divine' Bishop Potter, represents another great organisation, believing otherwise. If on a question of this kind, so important to the human race, nothing has been accomplished towards tolerance in centuries, it is at least discouraging to hope for anything which will be of practical value in settling the labour question.

In looking over other names and reading the utterances made by those present, one man, and one only, seems to the writer to be thoroughly and absolutely honest on the labour side. He was the representative of the locomotive firemen, and was reported to have said that he reserved the right to enforce the rights of those he represented. In other words, his union was willing to compromise and to arbitrate, provided arbitration resulted in its views being accepted; otherwise they would enforce its ideas, and this is the present idea of unionism, turn and twist as one may.

There was a splendid opportunity for those who represented a large number of employees to ask the labour representatives for a clear statement of what they wanted, whether it was an advance in wages, fewer hours of work, or anything else, and then to operate some works for six months or a year on the basis proposed. The writer would have no real right to make this suggestion if he had not personally tried the experi-

ment in connection with his business. In other words, without any request from any labour union, fifty-four hours were made a week's work by the writer, with the arrangement to stop work at eleven o'clock on Saturdays every Saturday in the year. A trial of a year and a half showed this plan to be highly satisfactory in its operation. It is appreciated by the men and those in the office, and the output has not fallen off.

Here, however, would have been the difficulty,—no organiser will ever tell exactly what he wants, or what his associates want. What is perfectly satisfactory to them to-day may be unsatisfactory to them to-morrow, and the labour leader must make his associates believe that it is unsatisfactory to them, otherwise he will lose his job. Nine hours a day might be satisfactory now, eight hours next year, and then something must be done to change the conditions after that,—perhaps six hours would be asked for. This difficulty may have been so well known to those who were at the conference that nothing was done in a practical way, but it is a commercial fact that where men are contented, better and more satisfactory work is obtained, and there is less opportunity for outside influence to come in and disturb the conditions. It was clearly proved by the strike last year at the works of the Dayton Cash Register Company, at Dayton, Ohio, U. S. A., where what is known as industrial betterment had been carried into practice in an elaborate way, that it was impossible to do all that was asked for by labour unions. The writer does not believe that porcelain-lined bath-tubs, good drainage, or prizes should offset poor wages, and this strike was most discouraging to those anxious to see labour troubles made less, and who thought that industrial betterment offered a solution of the problem.

In the purely machine line, or, to be more particular, in the trade of the machinist, men may not be as well paid as they should be. A man who takes a lot of plaster and puts it on a wall, coming within a thirty-second of an inch of being exactly right, does a good job; such a man gets $4 or more a day; but almost any machinist's job would be utterly ruined if a variation of a thirty-second of an inch were made from the measurement given.

The machinist's union wished to raise wages and shorten hours, and they most unfortunately put their request in a very undiplomatic way in their late strike by saying, "We want pay for an hour during which we do not work." This is a dishonest idea, to begin with, and it would naturally irritate one to have such a request presented. Proprietors are pretty obstinate, sometimes thoughtless, and at times unfair; in fact, the writer has had more trouble to get them to see a point than the workman. It is hard for a proprietor to admit that an idle shop is not losing money. Six hours a week lost are gone forever, yet he is perfectly willing to admit that if a man walks five miles in one hour, it would be a question whether he would walk five miles in the tenth hour. He knows that his money is a power, that he can have no physical discomfort if there is a strike, and he knows that men, unless they get work, will have physical discomfort.

On the other hand, with the one idea that in union there is strength, a workman wishes to get as many of his co-labourers into his organisation as he can, and certainly his method of getting them there and keeping them has, so far, proved a failure. A labour union depends upon numbers to make good its demands. There is a constant coming and going in the ranks, and a constant agitation to get in new men. There are comparatively few strikes where violence of some kind does not occur; it is always asserted by the leaders that the violence is not due to their organisation, but to misguided friends, though they know better. Why they cannot profit by the history of the past is beyond understanding.

The greatest labour organisation the world has ever known is that of Free Masonry. No one is ever asked to become a Mason, and yet its ranks grow and its splendid work goes on. Human nature is such that when anything can

be easily had it is not wanted; when it is difficult to obtain, everyone is after it. Several years ago the writer belonged to an association whose manager limited the membership, with the result that everybody in the town wanted to become a member, while other similar associations, with no limitation to their membership, were constantly scurrying round to fill their ranks.

Mr. Charles M. Schwab said that labour unions, as they now are, were unsatisfactory. This certainly is true, and appeals to everybody except the labour agitator and officers of the unions; and yet this is all wrong. Labour organisations ought to be, and the writer believes can be, made of the very greatest value to the world, and satisfactory to all. With all their bad features, with all their lack of thought, labour unions must be credited with at least opening up new lines of thought as regards working people's conditions; but the balance is decidedly against them. Their origin was in a country where there was a master and a man; in America there never have been any such conditions, and there never will be. In the country where unions were born a few made the country's government safe; in the United States it is just the reverse,— many make the government safe. The condition of Great Britain to-day shows that trades unionism as it now exists is very near its death, as it adopts the system of restricted output. This idea is so absurd that it must soon die, and the man who tells an apprentice boy that he is doing too much, or a fellow workman to go slow, loses the respect of his employers and stands in the way of the very thing his union wants,—shorter hours and more pay. Time will show him that if a man can make but one hat, say, a day, that hat will be so expensive that few men can buy it.

The labour unions desire to do away with piece work, because they believe that it hurts the workman; yet no union man would ever do anything but demand piece work when purchasing anything for himself. If he wished a suit of clothes, he certainly would not go to a tailor and tell him to make it and charge a fair profit, but he would at once demand a fixed price. The labour manager knows that a large percentage of machine shop work is done by the proprietors on the piece-work system, or so much for the job. Men must know what an article is going to cost or they will not buy, yet a union man wishes to have this risk run by the proprietor, with the possibility of a financial loss which may throw him out of employment.

What is wanted is a modification of the union systems on a plan which will make a union mean something to a proprietor other than trouble,— a plan by which a man, in presenting his union card, knows that the fact of his being a member of that association will help him, help the employer to find out just what he is, and all about him, and give some idea of his value. In other words, a grading of men must take place. No committee can determine what a machinist is worth; men are prejudiced at times, or unfair. But this grading can be done on a money basis.

A member of a union or association who has received $3 a day for one year might, for example, be given a white card; one who has received but $2.75, a red card; a $2.50 man, a green card; and one who is worth more than $3 could have a special card, say, with a star on it. Here is a system by which a proprietor could get a fair idea of what the man had been worth in other establishments, and is likely to be in his. On these cards the name of the man worked for last could be endorsed. If this system were in use the writer certainly believes all proprietors would be on the lookout for union men with white or star cards. This idea is one of the excuses for this article.

It will not meet with the approval of most labour agitators, but among them will be found some honest and determined men who will like it. It is certainly within the bounds of reason to make an organisation where the whole history of each member can be asked for and obtained. What an advantage it would be to the proprietor of a shop if, when he wants men, he could telephone or write to some local branch of a union

and get a man, or any number of men, to come and see him, and, when he gets the man whom he wants, pay into the association a small sum for obtaining him! This idea is another excuse for this article. To-day a union card does not mean anything; it is not a guarantee of anything, except that the man who holds it is a member of an organisation supposed to be made up of men who know their trade.

There is but one way in which machinists' wages can be raised, and that is by an increase of output of the man, and there is not one out of many thousands of machinists that run anything, from a cutting-off saw up, that could not, if he wished, increase his output at least by one-third in a month. If this were done, a proprietor would be more than glad to advance wages one-third. It would be a most obvious business advantage for him to do so, and any man could make this business arrangement with his employer if he wanted to, or he could find places where such an arrangement would be welcomed. It is, of course, presupposed that both the man and proprietor know what is now being done, and that guesswork will not be resorted to as a basis of advance.

A shop can be made to do a satisfactory amount of work on a nine-hour basis. But can it not be run on an eight-hour plan and do even better?

Suppose a set of men are started at seven o'clock in the morning and work until three o'clock, at which time a new set of men take hold and work until eleven o'clock, or eight hours in each shift, would not the earning capacity of the plant be greatly augmented at only an increased cost of material, productive labour, light, power, and some additional non-productive labour taxes, advertising and all interest, together with insurance, remaining the same? Could not such a shop, working sixteen hours a day, and having work of the proper kind, discount one working only nine hours a day?

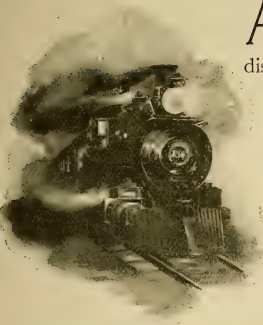
In the peace conference referred to at the opening of this article, it was pretty generally conceded that strikes do not pay. This is evident from the fact that from January 1, 1881, to June 30, 1894, strikes cost two hundred and eighty-five million dollars to employees and employers, the former paying two-thirds of this enormous sum, and the latter only one-third. Just what labour unions claim to have gained by this enormous sacrifice the writer does not know, but it is absolutely certain that any system of arbitration will be highly unsatisfactory unless those directly concerned put up money which they lose if they do not accept the decision of the arbitrating committee.

In conclusion, the writer would say that while the ideas suggested here cannot be expected to work much immediate good, he believes that if they are carried out they will eventually be found as satisfactory to others as some of them have been to him.

ROUGH-AND-READY ENGINEERING

AN EXAMPLE OF RAILWAY EMERGENCY WORK

By E. D. Meier



AT the close of the American Civil War the disbandment of the military railway service made free a number of railroad men and engineers who had learned their lesson of rapid construction, repairs, and transportation under circumstances of more difficulty than had ever been encountered in the profession before. Their services were eagerly sought by the promoters of the great Pacific railway systems, then just being pushed from the Missouri River westward and from the Sacramento River eastward.

Prominent among these men was Colonel E. C. Smeed, who became identified with the Union Pacific Railway, afterwards known as the Kansas Pacific Railway. He filled various positions in the engineering departments of the Pacific railways, and died in September, 1892, as chief engineer of the Union Pacific Railway, with headquarters at Omaha, Neb. Smeed had been in charge of bridge construction for General Sherman's army during the march from Chattanooga to Atlanta and afterwards from Atlanta to the sea. At the time of his death General Herman Haupt, in a short address on his life and services, stated that, "without the aid of Smeed, the march to the sea, instead of a triumphant success, would most probably have proved a disastrous failure."

During the campaign he performed the wonderful task of building a bridge about 900 feet long and more than 100 feet high across the Chattahoochie River in four and a half days. Haupt justly called this "the greatest feat in military bridge work the world has ever seen." It was one of those military bridges so well described by Lincoln as built of "nothing but beanpoles and cornstalks."

It was the writer's good fortune to serve with Smeed for some years on the Kansas Pacific Railway, and from his knowledge of the man he most heartily endorses General Haupt's encomium. And he has always considered this experience as a post-graduate course in practical engineering. One of a few instances of Smeed's ability to meet emergencies such as naturally arose in the construction and management of a new railway, which had rapidly been pushed into the trackless and then almost uninhabited plains of Kansas, well illustrates the remarkable capacity of the man.

THE BIG BLUE BRIDGE

A spring freshet is coming down the Big Blue River, and from Manhattan Station, on the west shore, a telegram announces that the middle pier of the bridge is sinking, and that the bridge is unsafe. To explain the situation a brief description of the bridge is necessary. Like most bridges over the rivers which the railroad, built along the north bank of the Kaw River, had to cross, it was composed of two spans of Howe trusses, each about 125 feet long. The shore piers were made of rubble masonry, backed with loose rubble, and with wing walls running a short distance landward.

The centre pier was of rubble masonry; the top and both ends were faced with ashlar. The up-stream end of the pier was slightly inclined and brought to a blunt point to serve as an ice breaker. The foundation consisted of more or less

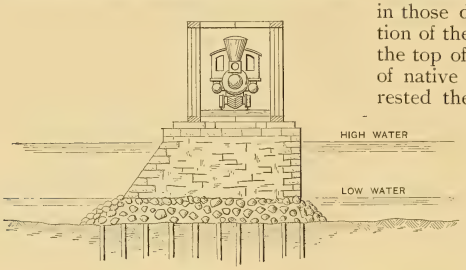


FIG. 1.—THE BRIDGE AND PIER

piles, generally less, with a bed of loose rubble dumped around the heads of the piles. This was brought roughly to a level by a little concrete, and on this foundation the pier was built.

In 1866 Portland cement was an article of luxury in the United States, and very little, if any, found its way to the West. The cements used were natural cements, and varied, of course, with the varying nature of the rock from which they were burned. Cement testing machines were unknown, and if any test was made it consisted simply in making a little flat cake of the cement, allowing it to set for twenty-four hours, and then judging of its strength by the amount of force required to break it with the fingers.

The rapidity with which it was necessary to build the Pacific railways and the difficulty of getting supplies to the front promptly made even this rude test seem a useless refinement in the eyes of the rough-and-ready engineers of the contractors. When the engineers of the railroad were sent out to inspect and accept each forty-mile section the bridges were finished, and there were no X-rays in those days to investigate the condition of the piers under the surface. On the top of the piers, bolsters, generally of native oak, were laid, and on these rested the lower chords of the Howe trusses. As nearly all were through bridges, pine bridge ties extended from chord to chord, about 20 inches apart, and on these the rails were spiked. The general appearance of pier and bridge is shown in Fig. 1, although the writer will not vouch for the piles there indicated.

It was such a bridge, then, that was reported as sagging and unsafe. Mr. Smeed was at this time attached to our engineering staff, without any special title, but in modern practice we would have designated him the "trouble man," for if a wreck, a washout, or trouble of any kind was reported along the road, everybody knew that it was solely and imperatively necessary to notify Smeed. It was like touching a button and he would do the rest.

It was the writer's good fortune to accompany Smeed on this expedition. We started in the forenoon, and, making all the speed possible on a mud-

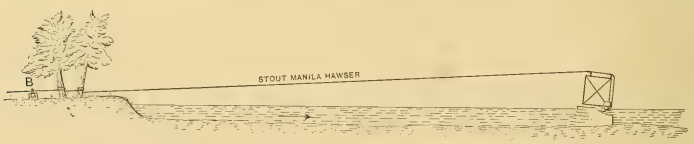


FIG. 3.—HAULING THE BRIDGE BACK INTO POSITION

ballasted road, arrived at the Big Blue River early in the afternoon. Smeed's first inspection of the pier showed the down-stream side crumbling away, so that the Howe trusses at that end were slightly tilted down stream. The middle and up-stream portions of the pier

were still solid. Shortly after Smeed's arrival a gang of bridge carpenters, with some timbers, joined him from the west. He immediately put them to work lashing and spiking heavy planks to the chords of the bridge at the mid-stream ends, so as to unite the two trusses into one continuous girder.

This done, Smeed spent an hour in the telegraph office, wiring orders east and west, then sat down to supper, during which he told jokes and spoke of everything except the Big Blue bridge. After supper he made a careful inspection of the west bank of the river, and found that it curved sharply to the east about 250 yards north of the bridge, the general direction of the current being from north to south. At this point the high bank extended in a sharp bluff out into the river, the low bottom having been cut away by the action of the current, as indicated in Fig. 2. On this bluff grew two or three stout cottonwood trees. The result of this inspection was another visit to the telegraph office and a hurry message to headquarters at Wyandotte.

At daylight the next morning heavy diagonal braces, which had been cut during the night, were ready to fit into the ends of the trusses. By placing a few ties across the south end of the pier a temporary abutment was formed on which whiskey jacks were placed, and by this means the trusses were carefully forced approximately back to their upright position, and the diagonal braces immediately fitted in. A few hours later two construction trains arrived at the ends of the bridge, each with a number of piles and a pile-driver. The one from the east had, in addition, some more important freight. It was a long, heavy hawser, such as are used by steamboats on the Missouri River. This hawser was carefully paid out along the bridge on the shoulders of the men, one end fastened to the down-stream lower chord, just over the centre of the pier, and the slack passed over packing strips on the two upper chords and lashed to the truss at each such point. The other end had meanwhile been passed to the west shore by a gang of labourers.

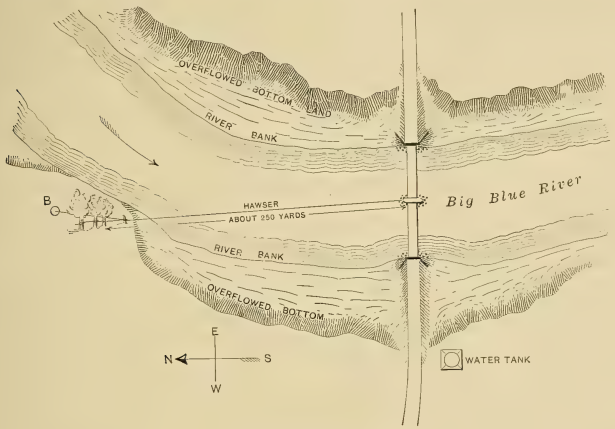


FIG. 2.—PLAN OF HAWSER ADJUSTMENT

A teamster with a strong four-mule team, hitched to a pair of lumber wheels, had reported to Smeed at the water tank, Fig. 2, early in the morning. One end of a long guy rope was now hitched to these wheels and the

other end lashed to the shore end of the hawser. The team was started up the bank to the cottonwood trees pulling the rope and the free end of the hawser through the shallow water of the overflowed bottom, until the former could be passed around the drum of a horse-power winch at *B*, Fig. 2. To this the mules were now attached, and the rope was wound in. The men at the bridge cast off, and the hawser was slowly and steadily pulled through the swirling, rushing current, finally rising clear of the water.

Smeed's purpose was now apparent. The hawser was soon hauled in by the winch as taut as possible, and then lashed to the two trees, assuming the position shown in Fig. 3. Thus it got such a purchase on the upper chords, rigidly blocked by means of the diagonal bracing, that the greater part of the weight of the two, now united, trusses was carried to the north or up-stream end of the pier, thereby relieving the down-stream end. The lower chords down stream had thus been barely eased from the blocking on which they were supported after being jacked into position. The two pile-drivers were now cautiously rolled out by hand towards the centre pier, and a pile was carefully driven on each side near the south end of this pier. This accomplished, other pairs of piles were similarly driven until there were six piles on each side of the pier. These were sawed off square, and 12 × 12-inch timbers were spiked on top of them, so that their upper surfaces were about 6 inches below the two chords of each truss. It was nearly dark by the time this was accomplished. Meanwhile, hardwood wedges had been prepared on shore, and these were carried to the cap piece and passed under the chords in pairs and brought to bite with small hammers.

Everything was now cleared away, Smeed himself, with the bridge boss and four bridge carpenters alone remaining on the pier. All now took their positions on the floor beams of the truss, a man told off to each wedge, with a heavy hammer, ready to drive. On a signal from Smeed, the four hammers fell simultaneously; a few blows from each and the wedges raised the down-stream chords from their temporary blocking, which, with a rush of rubble, splashed into the swift current.

The masonry had meanwhile been crumbling, so that only a few feet of the upper course on the north end remained in position. The four bridge carpenters were quickly moved to the up-stream end of the pier standing on the cap pieces of the piles. Again at Smeed's word their mauls struck the wedges. As soon as the weight was taken by the piles there was a crushing, crumbling sound, and with a great final crash the north end of the pier disappeared in the rushing water. The great weight concentrated on the pier end had held the top course and the side facings together at this one point. As it was removed, the ashlar slid out sideways, the cap-stones dropped, the inside filling of rubble rolled out like dry sand out of a bucket, and the pier was no more. The whole bridge now rested on two cap sills parallel to the pier that had been, —a safer support than it had ever had before.

The next day was occupied in driving two more rows of piles, capping them and wedging under the chords. Everything was then spiked fast, the diagonal bracing was removed, and the construction train from the east pulled across the bridge and into Manhattan yards, amid the cheers of the railroad men and the entire population of the village. The delayed mail trains from the east and west sawed by each other, and a telegram to headquarters announced that the traffic across the bridge had been resumed.

When, a few weeks later, low water-mark was reached, a vain search was made for the foundation. While there had been no visible attachment between it and the pier they had ended their career together.

MODERN FRENCH LOCOMOTIVE PRACTICE

By Charles Rous-Marten

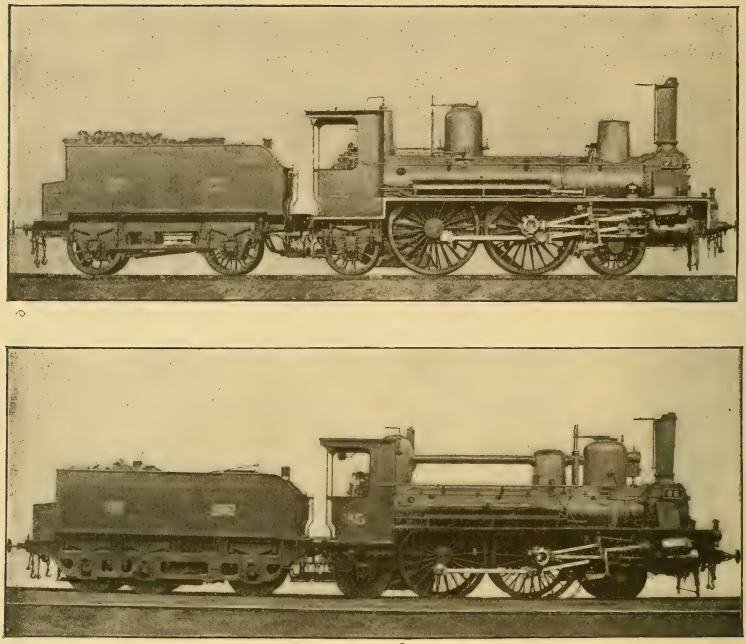
THERE can be no doubt at all that the locomotive practice of France, while possessing many characteristics of its own, has been influenced in a considerable degree by that of France's nearest neighbour, Great Britain. This is not surprising in view of the fact that Britain is the mother of railways, and that France noisly about twenty miles distant from the British coast.

This influence is seen most prominently of all in the fact that inside cylinders,—a peculiarly British plan,—have always been used to some extent in France, as also in Holland and Belgium, the next nearest countries to Britain, whereas over all the rest of the European Continent, as throughout the American Continent, inside cylinders are virtually unknown. And this prominent instance of British influence upon French practice is all the more strongly marked through its being confined almost exclusively to the two railways most closely adjacent to the English Channel, the Chemin de Fer du Nord and the Chemin de Fer de l'Ouest,—the Northern and Western railways,—which have their maritime termini at Calais, Boulogne, Dieppe, and Havre, respectively. On both of these railways the tendency has been, as in Britain, to employ inside cylinders almost exclusively, in express engines at any rate. Even now, when the triumph of the de Glehn compound locomotive has revolutionised French practice, the inside cylinder and the crank axle are retained, both being features of the de Glehn system. But prior to the advent of this system the standard express locomotives on the Northern and the Western railways were of distinctly British types.

On the former line two main types of inside-cylinder engines were used in large numbers. One of these constituted the so-called "Outrance Class," of which many were built, most, if not all, being still in use, although not generally on the best trains. These have not only inside cylinders, but also outside frames with outside bearings and cranks for the four coupled wheels, the last being also a method virtually peculiar to Britain, Holland, and Belgium, but practically extinct in the first-named country, save only on the Great Western Railway. The leading end is carried on a four-wheeled bogie. The principal dimensions are as follow: —

Diameter of cylinders	17 inches.
Length of piston stroke	24 inches.
Diameter of coupled wheels	6 ft. 10 in.
Total heating surface	1,082 sq. ft.
Steam pressure	156 lbs.
Weight in working order	43 tons.
Valve motion	Stephenson.

The other older Northern class was less used for express work, although it took its share of the duty also, but worked semi-fast, or slow, stopping passenger trains, or light express goods trains. These engines, which are still in use, are in reality much of the same type as Mr. Stroudley's famous "Gladstones" on the London, Brighton & South Coast line, or as Mr. Adams's mixed-traffic engines on the London & South-Western Railway, or as Mr. P. Stirling's similar engines on the Great Northern; that is to say, they have the leading and driving wheels coupled, their diameter being about 6 feet in the case of the French engine, with inside cylinders and a single pair of small trailing wheels. Apart from these British and French types just mentioned, there



FIGS. 1 AND 2.—NON-COMPOUND EXPRESS ENGINES ON THE PARIS-ORLEANS RAILWAY. POLONCEAU TYPE. CLASSES 51-76 AND 77-86

are very few instances of large leading and driving wheels being coupled in tender-engines, although this is the prevalent practice with regard to later locomotives. It is not being perpetuated in either Britain or France.

The plan undoubtedly possesses some advantage. It enables a larger proportion of a locomotive's weight to be profitably utilised for purposes of adhesion than when the two hinder pairs of wheels are coupled, and it largely diminishes the proportion of dead weight,—that is to say, of weight not available for adhesion; consequently, it reduces the total weight, and, relatively, the cost of material. Mr. Stroudley's "Gladstone," which weighed only thirty-eight tons, had just as much tractive force as many other British locomotives which weighed from ten to fifteen tons more, while its smaller length enabled turntables of less diameter to be employed. But although the "Gladstone" engines have always done excellent work, riding with remarkable smoothness and taking curves and facing points most readily with their 6-foot 6-inch leading wheels, there prevails a feeling too strong to be withstood that a smaller wheel, a free-running wheel, and preferably a bogie, is best to lead with, and that the use of a large coupled wheel in front may be attended with possible disadvantages not easy to define, yet having the potentiality of serious consequences. Therefore, while all the thirty-six "Gladstones" built by Mr. Stroudley, and, I believe, all the similar types on the Northern Railway of France, as well as on the London & South-Western and Great Northern railways of England, are still running, the type is not being multiplied either at home or abroad.

On the Western Railway of France the standard express type prior to the de Glehn advent possessed many characteristics of British Midland practice, especially in external aspect. The inside cylinders, the inside bearings to the coupled driving and trailing wheels, the splashers with their handsome double curve, and the neat general exterior of the locomotives have much in common with Mr. S. W. Johnson's Midland design. Their principal dimensions are as follow:—

Cylinders, inside, diameter	18 inches.
Piston stroke, length	26 inches.
Driving and trailing wheels, diameter	6 ft. 8 in.
Bogie wheels, diameter	3 ft. 2 in.
Heating surface, tubes	1202 sq. ft.
" " firebox	107 sq. ft.
Total	1309 sq. ft.
Steam pressure per sq. in	156 lbs.
Weight of engine in working order	43½ tons.
Valve motion	Walschaert

On the Paris-Orleans line outside cylinders have always preponderated, but three express locomotives were built by Monsieur Polonceau which differ among themselves in a few minor details, yet constitute a class by themselves. They bear the numbers 101, 102, and 103. All have inside cylinders, 17¼ inches in diameter, with 27½-inch piston stroke. The driving wheels are the second pair from the front; they are 7 feet in diameter, and are coupled to the third pair. The leading and trailing pairs, 4 feet 3 inches in diameter, are carrying wheels of the Mansell pattern, no bogie being employed. The boiler is no less than 16 feet 5½ inches in length, and has 1506 square feet of heating surface in the tubes, and 153 square feet in the firebox, or 1659 square feet in all. The steam pressure is 184 pounds. Gooch's valve motion is used, and the total weight of the locomotive is fifty-one tons in working order, of which the leading wheels carry twelve tons, the front coupled wheels fifteen and one-half tons, the hind coupled wheels fourteen tons, and the trailing wheels nine and one-half tons. The firebox is of the Polonceau pattern with a Tenbrinck water-arch or "bouilleur." There are two large steam domes, one placed close to the chimney, the other over the firebox. They are connected by a pipe which passes from one to the other through the cylindrical sandbox. Both the domes, as also the sandbox and the boiler, are encased in burnished sheet-brass. A six-wheeled tender is appended.

But the majority of the standard non-compound engines on the Paris-Orleans line are very different in style. They, like Nos. 101, 102, and 103, have their two middle pairs of wheels coupled and single pairs of leading and trailing wheels without bogies. These may be classed in two main groups of which almost all the other Orleans non-compound passenger engines are mere variants. Nos. 51-76 (Fig. 1) have 17½-inch cylinders, placed outside, 25½-inch piston stroke, 1600 square feet of heating surface, and 145 pounds steam pressure per square inch. They have four-coupled wheels, 6 feet 8 inches in diameter, with a pair of 4-foot leading wheels and a similar pair of 4-foot trailing wheels, the four-coupled wheels being placed under the middle of the boiler length. The total weight in working order is forty-six tons, of which the leading wheels carry twelve and one-half tons, the driving wheels fourteen tons, the rear coupled wheels thirteen and three-quarter tons, and the trailing wheels six and one-quarter tons. The boiler is of steel, the tubes are of brass; the leading and trailing wheels are constructed on the Mansell principle. The firebox is of the Tenbrinck design with water-arch. Almost the whole of the exterior of the engine is covered with burnished sheet-brass,—boiler, dome, and sandbox alike,—the last being cylindrical in shape and placed above the boiler. Practically only the chimney and smokebox are allowed to be without this polished brass draping.

Nos. 51-76 have small four-wheeled tenders. Nos. 77-86 (Fig. 2) are a later development of the same class of engine. They have boilers with 1500 square feet of heating surface, somewhat less than their predecessors, but higher steam pressure, viz., 213 pounds per square inch, and a second steam dome connected with the other dome by a long pipe which passes through the cylindri-

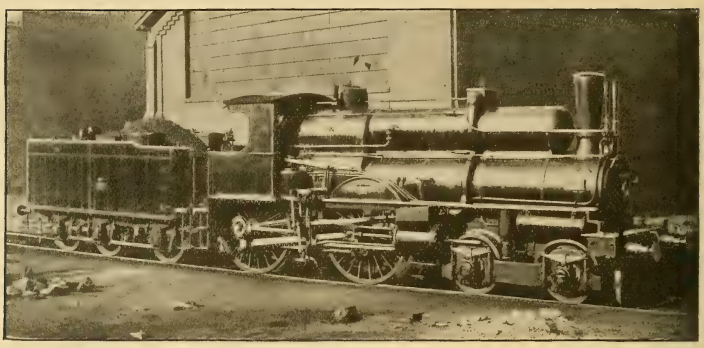


FIG. 3.—NON-COMPOUND EXPRESS ENGINE ON THE EASTERN RAILWAY. SALOMON TYPE WITH FLAMAN DOUBLE-BARREL BOILER

cal sandbox. The cylinders and wheels are of the same size as those of Nos. 51-76. Nos. 77-86 weigh each forty-seven and one-half tons in working order, namely, twelve and one-half tons on the leading wheels, fourteen and one-half tons on the driving wheels, fourteen tons on the rear coupled wheels, and six and one-half tons on the trailing wheels. They have six-wheeled tenders weighing thirty-five tons loaded.

Continuing my review of the French period of locomotive practice which immediately preceded the present compound era, I come next to the Midi, or Southern, Railway of France. Previously the standard type had 17-inch cylinders, placed outside, 23½-inch piston stroke, 6-foot 6¾-inch driving wheels, coupled, as in the case of the Orleans engines, to a second pair of wheels of the same size, the leading and trailing wheels being 4 feet 8 inches in diameter, no bogie being employed. Similar in most respects were the ante-compound locomotives on the Chemin de Fer de l'Etat, or State Railway of France. In the latter case the coupled wheels were 6 feet 7½ inches in diameter, the leading wheels 4 feet 4 inches, the trailing wheels 3 feet 8 inches, cylinders, placed outside, 17¼ inches × 25½ inches; total heating surface, 1308 square feet; boiler pressure, 184 pounds. The Paris, Lyons & Mediterranean line had a good many engines of very similar type to those which immediately preceded the compounds. These had leading bogies with 3-foot 3-inch wheels and coupled driving and trailing wheels 6 feet 6¾ inches in diameter; the cylinders, placed outside, were 19¾ inches in diameter, with a piston stroke of 24½ inches. The total heating surface was 1522 square feet, and the boiler pressure 156 pounds per square inch.

On the Chemin de Fer de l'Est, or Eastern Railway of France, the now almost universal de Glehn compounds were preceded by an express locomotive type of a very remarkable, and indeed almost unique, character. Its special peculiarity consisted in its boiler, which is of the Flaman type, having a double barrel, or two cylindrical barrels arranged one above the other (Fig. 3). The lower one may be regarded as the boiler proper. This is practically filled with tubes, and is connected with the upper barrel or steam drum by means of three large vertical apertures or short pipes. The steam and the larger part of the water are thus contained in the upper barrel or drum. By means of this ingenious device a very much larger area of heating surface is secured, together with greater cubic capacity of water space with enhanced freedom of steam generation. These engines have no less than 1664 square feet of heating surface in the tubes and drum, with 146 square feet in the firebox, or 1810 square

feet in all, while the fire-grate area is as much as 26 square feet, thus securing a marked facility of fuel combustion.

Forty engines of this type, numbered 801-840, were built. In the first twelve engines the crown of the internal firebox was of corrugated steel plate, which had some obvious advantages with respect to weight and expansion. It was found, however, to present defects in the way of adequately staying the sides of the firebox, and was, therefore, abandoned, the remaining twenty-eight engines having inside fireboxes with flat tops and constructed of red copper much strengthened by crossbars, which at the same time stayed the flat side of the firebox shell. Originally these engines had a water-arch, or "bouilleur," in the firebox, but this was subsequently abandoned, it being found that it required frequent renewal, at large cost, and, therefore, was not practically good, however theoretically admirable. Consequently, each "bouilleur," when worn out, had been replaced by the usual brick arch.

The Stephenson link motion is used with *D*-pattern valves, unbalanced, except in the case of three engines, one of which has an American type of Richardson balanced slide valve, and the two others Durant and Lencauchez slide valves with four distributors. The cylinders are placed outside; those of the first twelve engines were 19¼ inches in diameter, but in the other twenty-eight this was reduced by one inch, namely, to 18½; all have 26-inch piston stroke. The boiler pressure is 170 pounds per square inch. The leading end of the engine is carried on a four-wheeled bogie with 3-foot 6-inch wheels. The first twelve engines weigh fifty-five tons in working order; the last twenty-eight, fifty-six tons. Of these, thirty-two and thirty-three tons, respectively, are available for adhesion. I may observe, in passing, that these fine locomotives, designed by Monsieur Salomon, Ingénieur en Chef du Materiel et de la Traction of

FIG. 4.—FOUR-CYLINDER COMPOUND, SIX-COUPLED ENGINE ON THE NORD RAILWAY. TEN-WHEELER TYPE, CLASS 3121-3120

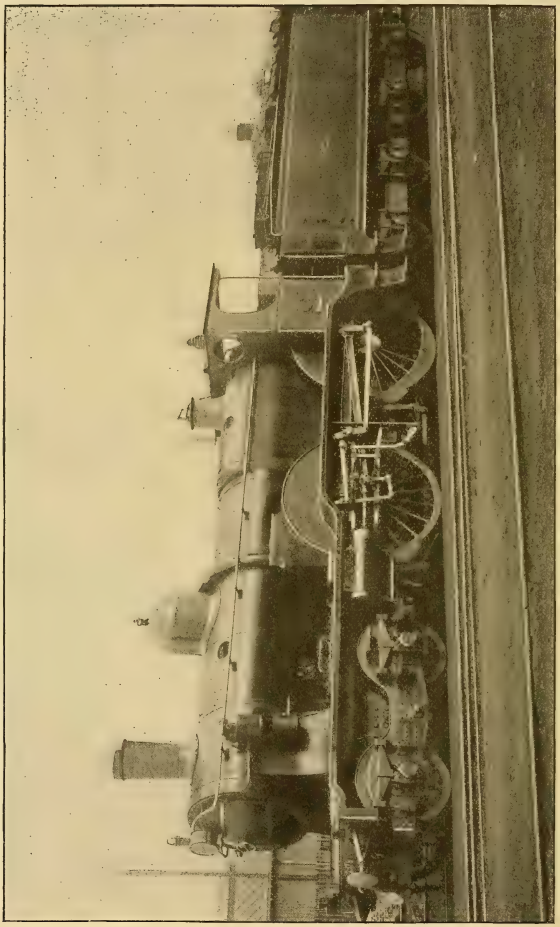


FIG. 5.—FOUR-CYLINDER COMPOUND EXPRESS ENGINE ON THE NORTHERN RAILWAY, WITH DOUBLE-BOGIE TENDER. CLASS 2161-2180

the Chemin de Fer de l'Est, while somewhat unattractive in outward appearance, have always done good work, experience having shown them to be inferior to the new compounds only in respect of quickness in starting with heavy loads.

Having thus traversed the general ground of modern French locomotive practice as exhibited in the standard passenger engines constructed on the leading railways up to the time of the general adoption of the compound method,—virtually all the engines referred to being still employed in regular work,—I come next to the all-important innovation which in the course of a single quinquennium has practically revolutionised locomotive engineering in France. This consists in the introduction and all but universal adoption of the four-cylinder compound method. I need not digress into a dissertation upon locomotive compounding in general; it would occupy far too much space. I content myself with saying, in brief, that with one exception, to be noticed when I come to deal with the goods engines of the class, locomotive compounding in France was purely experimental and sporadic until the arrival of the plan which I feel justified in associating with the name of Monsieur Alfred G. de Glehn, Directeur-Génerale of the Société Alsacienne de Constructions Mecaniques, whose vast works are situated respectively at Belfort and Mühlhausen, that is to say, on both sides of the Franco-German frontier.

I may observe, in passing, that Monsieur de Glehn is an Englishman by birth. His plan was originally applied to an express engine, No. 701, belonging to the French Northern Railway. In this engine, however, the four driving wheels were not coupled; each pair was worked independently, and was driven, respectively, by two high-pressure cylinders inside the frames and two low-pressure cylinders outside. Several years' trial with this engine gave results so satisfactory that it was decided to apply the principle on a larger scale to the next batch of express engines that were built. In view of the fact, however, that in spite of all theoretical means being adopted to ensure synchronism in the working of the high and low-pressure parts this could not be satisfactorily secured, it was decided that in all future cases the driving wheels should be coupled by side-rods. Accordingly, two engines of the de Glehn type thus amended were built for the French Northern Railway, and one or two also for the Paris, Lyons & Mediterranean line The former were given 13½-inch high-pressure cylinders, placed outside; 21-inch low-pressure cylinders, placed inside; 25¾-inch piston stroke, and driving wheels 7 feet in diameter, with new tires. The two rear pairs of wheels were the drivers, and a four-wheeled bogie was placed under the front end of the engines.

These dimensions and points of construction were adhered to in all the engines subsequently built for the Nord up to the advent of the ten-wheeled "Atlantic" type, to which I shall refer later. But although there was this uniformity among all of the sixty Northern engines of the eight-wheeled order, there was a steady increment of boiler power and weight in each batch as it came out from time to time. Thus the boiler heating surface, which was 1670 square feet, had, in No. 2121, increased to 1890 in No. 2180, while the steam pressure was augmented from 199 pounds per square inch in Nos. 2121-2137 to 213 pounds in Nos. 2138-2180, the fire-grate area at the same time being enlarged from 21 square feet to 28 square feet, and the total weight of the locomotive in working order from forty-seven to fifty-two tons.

Apart from the advantage which is claimed for the compound system,—that the steam which has already been used once in the high-pressure cylinders is employed a second time at a lower, but still efficient, pressure in the second pair of cylinders, with the benefit of economy in respect both of steam and of power,—it is also contended that three special points of merit belong to the de Glehn system of compounding, namely, (1) the provision for direct admission of steam to the intermediate reservoir

which enables the tractive power of the engine to be temporarily almost doubled in cases of emergency; (2) the three-way valve, by means of which the exhaust from the high-pressure cylinder can be discharged, if desired, into the atmosphere, thus avoiding excessive back pressure; (3) the setting of the high-pressure and low-pressure cranks on each side of the engine at an angle of 162 degrees to each other, which materially facilitates the exertion of starting, besides exercising a valuable effect in respect of balancing. That these and other advantages were possessed not only theoretically, but very practically by the new compounds, was soon demonstrated conclusively in actual practice. The engines were speedily multiplied to so large an extent that the first year of the twentieth century actually saw more than 1000 of them at work respectively in France, Germany, and Switzerland, by far the larger portion of this number, however, being in France, the country of their origin.

It is a remarkable, and I believe absolutely unique feature in this triumphal progress of the de Glehn compound system, that it has secured adoption as a standard-construction type on every one of the great railways of France, namely, the Nord, Orleans, Midi, Etat, Est, and Ouest. This is all the more astonishing when one takes into consideration the characteristics usually, but, as this experience proves, not always accurately, attributed to the French temperament. That is to say, it might have been conjectured that the love of personal distinction, which seems so prominently developed in the French race, might have led each chief mechanical engineer of a French railway to strive at producing a different and distinctive type of his own instead of adopting any invention of an engineer who, however able and eminent, is, from the railway official viewpoint, an outsider. Such a tendency has long been very noticeable in British locomotive practice, but, strangely enough, in France, where it might have been expected to be found *in excelsis*, it proves to be non-existent. True, the various chief mechanical engineers have designed the new engines for their respective systems, as regards various details, dimensions, and local peculiarities, in accordance with the particular views entertained by each of these gentlemen. But all have agreed in adopting the one method of compounding and the design and general arrangement of the locomotive which the use of that method necessitates.

It needs but a glance at the compound engines of the different companies to show this instantly, and the self-abnegation exhibited by these various distinguished engineers becomes all the more noteworthy and admirable when it is recollected that one or two of them had already perfected compound systems of their own. This was particularly the case as regards M. du Bousquet, the very able Ingénieur-en-Chef du Materiel et de la Traction of the Chemin de Fer du Nord, who, on his accession to chief office on that important railway, had a very ingenious compound system of his own which he contemplated introducing when the next new express engine should be built. But his experience with the de Glehn system soon convinced him that, in that system, he had one which adequately fulfilled all requirements, and which was incomparably superior to any previously tried in France. And so M. du Bousquet, placing his scientific judgment and his duty to the railway company in the first place, at the expense of his own personal ambition, deliberately decided that the de Glehn compound should thenceforward be the standard for all locomotives constructed for the most important work on the Northern line.

Speedily the Southern Railway followed the Northern lead, and ordered a number of engines which differed from those of the Northern merely in subordinate details and minor dimensions. Almost simultaneously the Paris, Lyons & Mediterranean, by far the largest railway system in Europe, beginning with two or three experimental de Glehn compounds, established the method as a standard one for its system, and ordered forty engines which differed from those of the Nord and Midi only in having some-

what smaller dimensions and in being fitted with certain appliances which were designed for the purpose of diminishing wind resistance, but which, as I shall explain subsequently, are, in my opinion, mere useless and unsightly excrescences.

In its turn, the Western line tried a couple of four-cylinder compounds, and as a result of the trial also adopted them as its standard type. Several, almost identical with those of the Nord and Midi, were supplied to the Chemin de Fer de l'Etat, or State Railway of France. By this time, it will be noticed, they had obtained a footing on every leading French line except the Orleans and Eastern railways. It now became their turn to conquer these likewise. Two or three years ago it was decided by the Orleans administration to accelerate materially the principal expresses in each direction between Paris and Bordeaux. Doubts were entertained whether the locomotives of the types already described as in use on that line would be capable of grappling with the augmented duty thus imposed, namely, of hauling heavier loads at far higher speeds than hitherto.

Just at this period M. Polonceau, the eminent Ingenieur-en-Chef du Materiel et de la Traction, retired, and was succeeded by M. Solacroup, who now so very ably fulfils the arduous duties of that post. It was decided to procure twenty locomotives compounded on the de Glehn four-cylinder system, and almost identical in design and dimensions with the Nord engines Nos. 2161-2180 and with the Midi engines of the 1751-class. Pending the arrival of these new locomotives the Orleans Company actually hired several of the same type from the Nord and Midi lines, respectively, and these continued to perform the most important express duty between Paris and Bordeaux up to the time the Orleans Company's own engines were ready.

Meanwhile, on the Chemin de Fer de l'Est, M. Salomon had been making a series of elaborate experiments with No. 1760, of the Midi, in comparison with his own engines, already described, of the "801" double-boiler order. These trials were exceptionally extensive and exhaustive in their character, and the result has been told by M. Salomon in an admirable monograph. Practically, it was to show the compounds distinctly superior to the non-compounds in respect of the facility with which they started heavy loads and the rapidity with which they attained high speeds. And so, finally, the Eastern Company, in its turn, adopted the four-cylinder compound as its standard express type, at once ordering no fewer than thirty-two to be in readiness for the heavy Exhibition traffic of the year 1900. The Eastern engines are distinctly more powerful than the others of the same order that have yet been referred to, being fitted with larger boilers, having 1988 square feet of heating surface, higher steam pressure (228 pounds), and with cylinders the same size as those of the Orleans and Midi compounds, but having driving wheels 4 inches smaller, namely, 6 feet 8 inches in diameter. I may observe, in passing, that it has been deemed preferable to work the engines at a pressure somewhat less than that for which their boilers were constructed; that is to say, they use 213 pounds of steam per square inch, as do most of the other engines recently built on the same plan.

The principal dimensions of the French four-cylinder compounds with four-coupled wheels are as follow:—

	Nord.	P.L.M.	Est.
Cylinders H.P.(2)(outside)	13⅜ in.	13⅜ in.	13¾ in.
Cylinders L.P. (2)(inside)	20⅞ in.	21⅝ in.	21⅝ in.
Piston stroke	25¼ in.	24¾ in.	25¼ in.
Coupled wheels (2) diam.	7 ft.	6 ft. 6¾ in.	6 ft. 9½
Total heating surface	1891 s.ft.	1593 s.ft.	1988 s.ft.
Grate area	28 s.ft.	25½ s.ft.	27 s.ft.
Steam pressure	213 lbs.	213 lbs.	228 lbs.
Weight in working order	51½ tons	49 ¾t'ns	58¼ t'ns

The similar engines on the Midi, Orleans, and Etat lines differ but slightly from those of the Nord, given above; the Ouest engines are very much the same in dimensions as the Paris, Lyons & Mediterranean engines.

In the year 1895 a fresh development took place. The Southern Railway required locomotives of increased power to work their fast trains over the excessively severe gradients of the Pyrenean section of that system, some of which

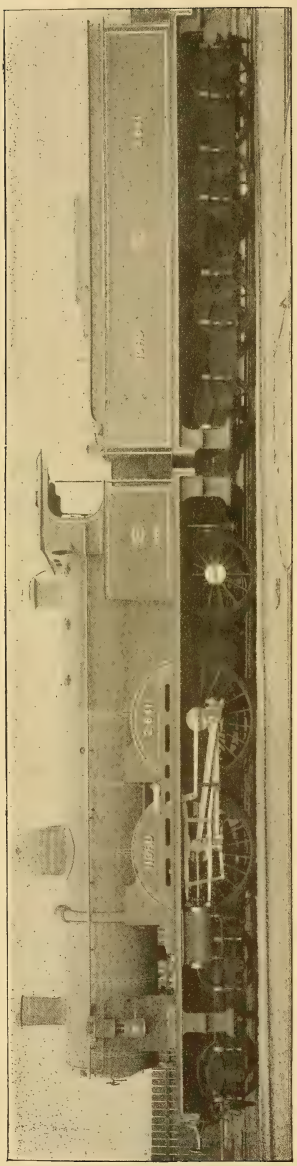


FIG. 6.—FOUR-CYLINDER COMPOUND EXPRESS ENGINE, ATLANTIC TYPE, ON THE NORTHERN RAILWAY. LATEST CLASS, 2641-2642. DE GLEHN SYSTEM

are as steep as 1 in 33 and even 1 in 31. What is known in the United States as the "ten-wheeler" type was adopted, three pairs of wheels being coupled and a smaller diameter being used, while the leading four-wheeled bogie was retained. Twelve of these ten-wheeled locomotives were constructed for the Southern line, and the results were so good that in 1897, after some experiments with a Midi engine of this type, the Chemin de Fer du Nord ordered a number of this type, and ultimately in all procured no fewer than ninety of the same class and of virtually identical dimensions. All have six coupled wheels, 5 feet 8¾ inches in diameter; two 13¾-inch high-pressure cylinders (outside); two 21½-inch low-pressure cylinders (inside); 25¼-inch piston stroke; 1950 square feet of heating surface, and 213 pounds steam pressure.

These powerful locomotives proved capable not only of hauling long goods trains weighing 1000 tons at average speeds of twenty-five miles an hour, but also of doing excellent work on heavy passenger expresses, ascending severe gradients with remarkable facility, hauling large loads, and readily attaining speeds of seventy to seventy-two miles an hour on falling grades. They are coming more and more into use on regular passenger express service.

Next, in 1898, the Paris, Lyons & Mediterranean, the Est, and the Ouest railways obtained no fewer than 150, 26, and 25, respectively, of these engines, those of the Paris, Lyons & Mediterranean, however, having larger boilers, with 2040 square feet of heating surface and somewhat smaller driving wheels, 5 feet 5 inches in diameter. The Eastern Railway's locomotives of this class are considerably larger than any of the others, having boilers with 2210 square feet of heating surface and a steam pressure of 228 pounds, although the cylinders and wheels are the same as on the other lines. The Est engines of the type under notice weigh no less than sixty-four tons seven cwt. in working order, and are among the heaviest locomotives in France. The Midi line has procured fifteen more of them, but having 5-foot,

3-inch coupled wheels instead of 5-foot 9-inch, and on the same railway a still newer variant is being constructed with a fourth pair of coupled wheels for the Pyrenean service. The Orleans line brought out twenty-five of the ten-wheelers in 1899. All have proved exceedingly useful machines, and they are likely to be extensively multiplied.

Among the latest French departures as regards passenger engines may be mentioned (1) the two enlarged compounds of the "Atlantic" type, designed by M. du Bousquet on the de Glehn four-cylinder compound system for the best express duty on the Northern Railway; (2) the ninety locomotives, enlarged editions of the standard compounds of the Northern line already described (1) in having much larger boilers, 16 feet 8½ inches in length, or 13 feet 9½ inches between the tube-plates, and 4 feet 9¼ inches internal diameter instead of 4 feet 5¼ inches, with 2275 square feet of heating surface instead of 1891 square feet, and 228 pounds of steam pressure instead of 213 pounds; (2) in having driving wheels 3½ inches smaller, viz., 6 feet 8½ inches instead of 7 feet in diameter; (3) in having an additional pair of carrying wheels behind the firebox; (4) in having 22-inch low-pressure cylinders instead of 20⅞-inch; and (5) in weighing sixty-three tons instead of fifty-one and one-half. One of these engines,

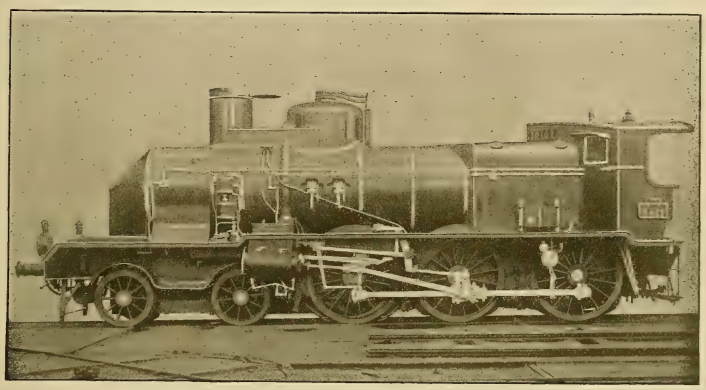


FIG 7.—FOUR-CYLINDER COMPOUND SIX-COUPLED BOGIE ENGINE ON THE PARIS, LYONS & MEDITERRANEAN RAILWAY. TEN-WHEELER TYPE. CLASS 2401

C.21—C.60 compound type, for the Paris, Lyons & Mediterranean; (3) the American engines of the Vauclain four-cylinder compound type procured for the Chemin de Fer de l'Etat, Nos. 2801-2805; and (4) the other American engines of the non-compound "Atlantic" class, procured also for the Etat line.

Of these, the two first referred to, built for the Chemin de Fer du Nord, Nos. 2641 and 2642 (Fig. 6), it may be said without exaggeration that no more efficient locomotives for fast and heavy express service have ever yet been produced. They differ from the standard compounds of the Northern line already described (1) in having much larger boilers, 16 feet 8½ inches in length, or 13 feet 9½ inches between the tube-plates, and 4 feet 9¼ inches internal diameter instead of 4 feet 5¼ inches, with 2275 square feet of heating surface instead of 1891 square feet, and 228 pounds of steam pressure instead of 213 pounds; (2) in having driving wheels 3½ inches smaller, viz., 6 feet 8½ inches instead of 7 feet in diameter; (3) in having an additional pair of carrying wheels behind the firebox; (4) in having 22-inch low-pressure cylinders instead of 20⅞-inch; and (5) in weighing sixty-three tons instead of fifty-one and one-half. One of these engines, specially tested by myself at the express invitation of the Northern Railway authorities, ran with a train of 305 tons, exclusive of engine and tender, from Paris to St. Quentin, ninety-five and three-quarter miles, in 90 minutes 52 seconds, start to stop, averaging 62.1 miles an hour up the 13-mile bank of 1 in 200, and never going below 59.2 miles an hour; also maintaining 75 miles an hour on the level and slight rise, all these with a load of 305 tons behind the tender. On down grades the speed was kept rigidly to the legal limit, 74.5 miles an hour; otherwise a still higher start-

to-stop average could have been obtained.

In a second trial the same engine, No. 2641, took a load of no less than 365½ tons (French), or 360 English tons, on the first stage of the famous Nord Express from Paris to Cologne, Berlin and St. Petersburg, viz., to St. Quentin, a distance of about 95¾ miles, which includes one bank of 1 in 200 for 13 miles continuously, and another of 1 in 333 for 10 miles. With that enormous load of 360 English tons behind the tender, —or 468 tons, if the weight of engine and tender were included,—the engine ascended the 13 miles of 1 in 200 at an average speed of 56 miles an hour, the lowest speed point being 52.2, while on the latter part of the rise the rate was as high as 57.1. On the length of level and slightly rising grades from Creil to Tergnier, a steady rate of 64 to 70 miles an hour was sustained. Tergnier, 81¾ miles from Paris, the same distance as Amiens, was passed in 80 minutes 44 seconds from the start, but thenceforward, as the train had got train came to a signal stop just outside St. Quentin station in 96 minutes 13 seconds from Paris, the final stop inside being in 97 minutes 31 seconds, in spite of signal delays of altogether 2½ minutes.

On another occasion No. 2641 took the Paris-Calais corridor dining train up the 8-mile bank of 1 in 125 between Calais and Boulogne at a minimum speed of 52 miles an hour, and subsequently up the 26 miles of 1 in 250 and 1 in 333 at a minimum rate of 65 miles an hour, the weight being 267 English tons behind the tender; while in the opposite direction, with a 235-ton load, the 23 miles of 1 in 250 and 1 in 333 were ascended at 65 to 68 miles an hour, and the Caffiers incline, of 1 in 125, was actually climbed at an average of 61.8, the absolute minimum being 55. In a special downhill test the engine also attained 85.8 miles an hour. I have no instances among all my voluminous records of equally remarkable achievements.

The newest Paris, Lyons & Medi-

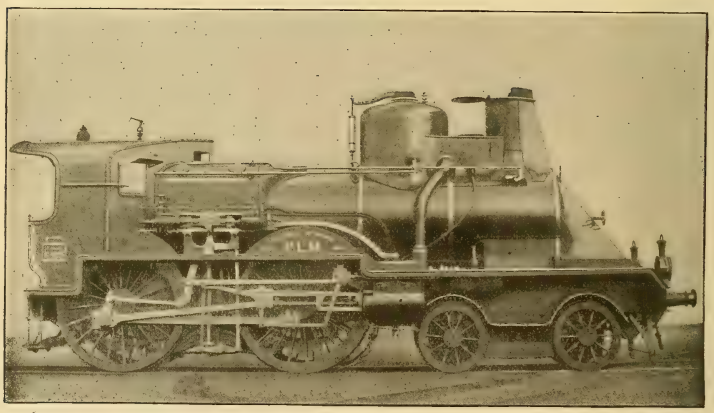


FIG. 8.—FOUR-CYLINDER COMPOUND EXPRESS ENGINE ON THE PARIS, LYONS & MEDITERRANEAN RAILWAY. CLASS C.21—C.60

materially in front of its booked time, although two signal checks were encountered, the driver, unfortunately, had to ease down; nevertheless, the terranean compounds are ninety in number, Nos. C.61—C.150 (Fig. 9). These have far larger boilers than the C.21—C.60 class, the internal diameter

of the boiler being 4 feet 8¾ inches instead of 4 feet 4 inches, and the total heating surface 2040 square feet instead of 1594, while the weight is fifty-one and

provision involve extra cost or any other drawback.

Unfortunately, a very serious drawback to the wind-cutter construction

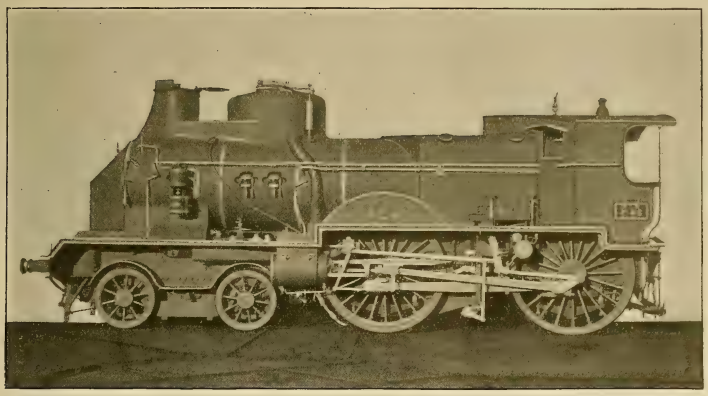


FIG. 9.—FOUR-CYLINDER COMPOUND EXPRESS ENGINE ON THE PARIS, LYONS & MEDITERRANEAN RAILWAY. CLASS C.61—C.150

one-half tons instead of forty-nine and three-quarters. But the wheels and cylinders remain the same size as in the earlier types. I have already mentioned, in connection with the Paris, Lyons & Mediterranean compound engines, the "wind-cutter" prows with which they are fitted. In these later locomotives the shape is considerably altered. The principle, however, remains the same, viz., the mitigation of the adverse resistance of the atmosphere by presenting a wedge-shaped front. This is fitted not only to the smokebox, but also to the steam dome, sandbox, and cab. That the resistance of a wind dead-ahead, or of the still atmosphere in calm weather, is, to some trifling extent, mitigated by this mode of construction, may at once be frankly admitted. But in reality it is so small in amount as to be practically negligible. Experiments have shown that the difference in the atmospheric resistance encountered by a flat-fronted cylindrical body and one with a pointed, or angular, or beaked, or prow-shaped front, is relatively so small as to be hardly worth providing against if such exists, although it seems generally to have escaped notice. While a head wind or a still atmosphere hinders the fastest train but little, any wind in the slightest degree on one side of the course, still more if right abeam, as it is nautically phrased, and most of all if on either "bow,"—that is to say, partly ahead and partly on one side,—constitutes a hindrance of a most serious nature, because, by forcing the flange of every wheel on one side of the whole train against the lee rail it acts as a very powerful brake. I have found in direct experiments that such a wind, if strong, will often reduce the speed of a fast express by 30 or even 40 per cent. The fatal disadvantage of the wind-cutter construction is that it exposes the greatest possible amount of surface to the most mischievous wind of all, and so increases the resistance in a formidable degree, instead of diminishing it.

Consequently, I am compelled to regard the plan as objectionable, although it has been adopted on the Etat line, and also in the case of a few non-compound express locomotives, one of

FIG. 10.—NON-COMPOUND EXPRESS ENGINE, ATLANTIC TYPE, ON THE STATE RAILWAY

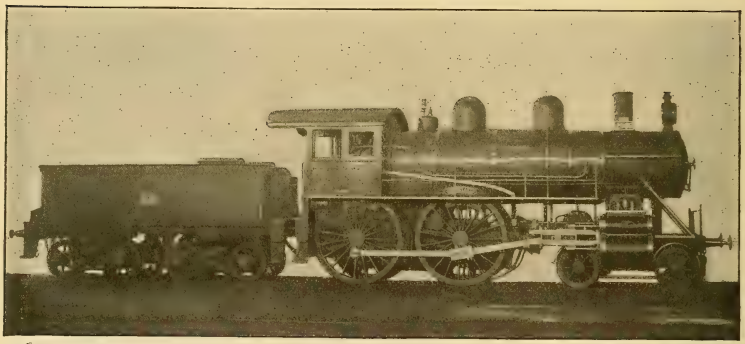


FIG. 11.—FOUR-CYLINDER COMPOUND EXPRESS ENGINE ON THE STATE RAILWAY. VAUCLAIN TYPE BOTH ENGINES WERE BUILT BY THE BALDWIN LOCOMOTIVE WORKS, OF PHILADELPHIA, AND HAD BEEN SHOWN AT THE PARIS EXHIBITION OF 1900

which, No. 2754, was in the Paris Exhibition of 1900. This has 6-foot 7½-inch driving and trailing wheels coupled, outside cylinders 17¾ inches × 25½ inches, 199 pounds of steam pressure, and leading four-wheeled bogie, but possesses no specially noteworthy features.

The two classes of American design present the novelty of purely American types working on French metals. The eight-wheeled engine, No. 2805, "Montlieu" (Fig. 11), is a four-cylinder Vauclain compound built at the Baldwin Works, Philadelphia. It has two 13-inch high-pressure cylinders, placed outside and superposed on two 22-inch low-pressure cylinders, the two pairs of pistons working on single cross-heads, and having a stroke of 26 inches. The coupled driving and trailing wheels are 7 feet in diameter, and there is a leading four-wheeled bogie. The boiler is of the waggon-top order, made of steel, 4 feet 8½ inches in diameter internally, and having 1892 square feet of heating surface, including 128 feet in the firebox. The grate area is 28½ square feet, the steam pressure 215 pounds, and the weight fifty-four tons. The other Midi engine, No. 2903, "Montaigu" (Fig. 10), is of the "Atlantic" type, and non-

compound. It has outside cylinders, 17 ¼ × 26 feet; 7-foot coupled wheels, 213 pounds steam pressure, bogie in front, and a single pair of carrying wheels behind the firebox. It weighs sixty-three tons.

Such, then, is as full an outline as my space permits of the prevalent features of modern French locomotive practice as applied to the principal classes of passenger engines in use on all the chief railways of France. With the goods engines I must deal still more briefly, and, indeed, the subject does not demand extended treatment. With the exception of the very large and powerful compounds of the "ten-wheeler" type, already described as used for all sorts of mixed traffic, the French goods engines are mostly either of the ordinary six-coupled kind or else, and often more prevalently, eight-coupled. These latter are especially numerous on the Chemin de Fer du Nord, where they perform most of the regular goods traffic. But there are a large number of eight-coupled goods locomotives on the Paris, Lyons & Mediterranean of the four-cylinder compound class, with wheels either 4 feet 1 inch or 4 feet 11 inches in diameter, 1600 to 2183 square feet of heating surface, and cylinders of much the same size as those of the passenger compounds.

The Northern line has twenty four-cylinder compounds on the Woolf system, with cylinders placed tandemwise. These have 4-foot 3-inch wheels, 15-inch high-pressure cylinders, 26-inch low-pressure cylinders, and 25½-inch piston stroke, 1338 square feet of heating surface, and 142 pounds steam pressure. They appear to do very satisfactory work in their particular class of service. It may be noted that these engines, which were built in 1889, have three piston-rods and one valve to each pair of tandem cylinders, while there is no intermediate steam receiver, the steam traversing directly from the high-pressure to the low-pressure cylinder. A three-cylinder compound has been tried experimentally on the Nord, having one high-pressure cylinder placed inside and two low-pressure cylinders placed outside, all driving the same pair of wheels, which is coupled to two other pairs, a fourth (carrying) pair having radial axles. This design has not been perpetuated.

Tank engines in great variety are largely used in France, as in Britain, for suburban, and branch, and shunting work; but they present no special features of interest, and so numerous are the types that even the briefest description would occupy a quite impracticable amount of space. They would need to be treated separately were the subject sufficiently interesting.

Glancing cursorily at a few details of French practice, I may remark that most of the newest boilers are of the Belpaire type, generally of mild steel with Serve tubes of the internally-ribbed pattern, and copper fireboxes. Extended smokeboxes are largely in use, often fitted with a horizontal movable grid just below the chimney for the interception of sparks. The Walschaert valve gear is in large and increasing use, and bids fair to become the standard type in France. Direct-acting safety valves are preferred to the old lever type, and the adjustable blast-pipe is largely employed, with distinct advantage. Six-wheeled and four-wheeled tenders are most prevalent, but latterly eight-wheeled tenders, placed on two bogies, have come a good deal into vogue for express work involving long runs without intermediate stops.

It may be added that a good many old six-coupled and eight-coupled non-compound locomotives are being rebuilt by the Paris, Lyons & Mediterranean and Midi railways as two-cylinder or four-cylinder compounds, with very favourable results.

There can be no doubt that the compound locomotive has "come to stay" in France. The advantage of the system is forcibly and concisely stated by Professor Sauvage, Assistant Mechanical Engineer-in-Chief to the Chemin de Fer de l'Ouest, thus:—"If compound locomotives with four cylinders cost a little more than ordinary two-cylinder locomotives, this excess is largely compen-

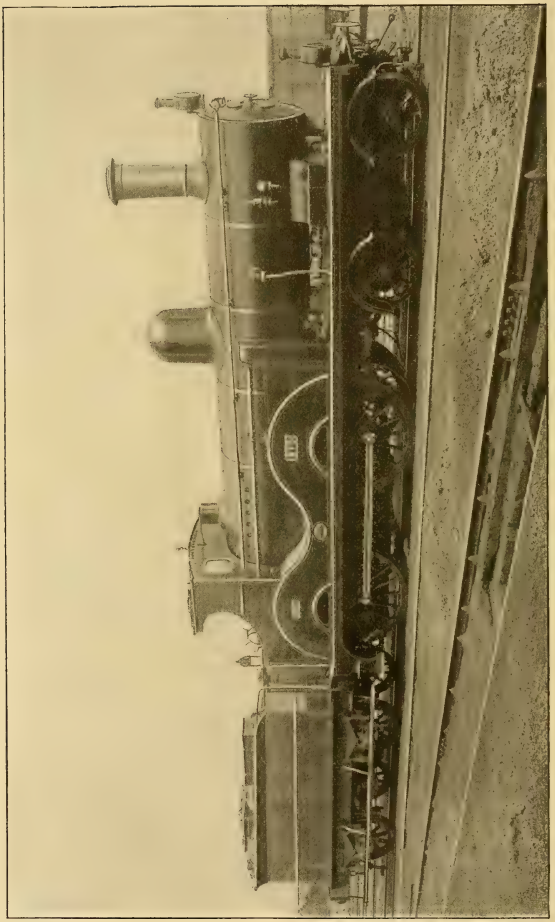


FIG. 12.—NON-COMPOUND EXPRESS ENGINE ON THE WESTERN RAILWAY. STANDARD TYPE

sated for by economy in fuel, because the cost of up-keep and repair does not appear to increase."

My own investigations lead me to agree entirely with this view of the matter, and to add that they possess the still more valuable quality of economising steam, and, therefore, power.

The illustrations accompanying this article are reproductions of photographs by Mr. F. Moore, of Charing Cross Road, London.

THE CHINESE JUNK

By W. G. Winterburn, Victoria Foundry, Hong Kong

WITH the present interest in China the writer, having spent a number of years in that country, closely connected with engineering and shipbuilding, recently presented, before the Institute of Marine Engineers, the following data concerning that typical craft of the Chinese shipbuilding industry,—the Chinese junk.

There are sinologues who claim every new invention as only a resurrection of something Chinese, and it is a fact that many so-called modern ideas are found utilised in the vessels of the Chinese and have been in vogue with them from time immemorial. They discovered the mariners' compass; also the principle of the balanced rudder. On the West River may be seen the prototype of the turret ship, bearing an extraordinary resemblance to the North of England monstrosities; and if the gallant captain, who, a year or two ago, discovered and published the fact that sails perforated with holes were more effective than whole canvas, were to visit the Yangtse he would see more of that kind of sail than any other; some, indeed, are so ragged that there is more space than cloth. This is only in keeping with most things in the Middle Kingdom. Its cities, pagodas, ramparts, and walls are all permeated with "the breath of things which have had their day."

But the Chinaman is very much alive, nevertheless. Conservative as he is, if the laws of his country permitted he would not be slow to accept novel ideas after he has seen them put into practice. The Chinaman does not experiment; it does not pay. He discovers things by accident or evolution and adopts them, and if an imported improvement is demonstrated to be such, it is often a mistake to suppose that he will have none of it.

The delta of the Pearl River is probably the greatest shipbuilding district in China, and it is there that the contrast between the old and the new is most marked. In Hong Kong may be seen on the stocks junks, extraordinarily shaped cargo boats, beautifully modelled wooden steamers, steel stern-wheelers, steam yachts, gunboats, and the most up-to-date small cargo and passenger vessels. The Chinese themselves, without foreign assistance, are capable of building, and do build, capital small wooden steamers up to 400 tons, and this, too, in Canton, where it is not easy to purloin drawings and ideas from European shops, because there are none there.

Not only the large centres of population, but many of the villages on the rivers have important shipbuilding industries. Macoa turns out an enormous number of junks and sampans every year; Whampoa was a large shipbuilding place in Captain Cook's time, and, according to students of Chinese lore, before the flood. It is curious that a tradition exists that once "ages ago there lived a good patriarch of his village who dreamed several times that there would be a great inundation; he warned his neighbours, but they only

THE WEST RIVER AT CANTON, CHINA, WITH JUNKS AND OTHER ORIENTAL CRAFT

scoffed; he gathered his family round him, and such of his friends who believed, and they took their goods and chattels, with provisions, live stock, etc., up the highest mountain in the vicinity. The flood came on the appointed day and devastated the country. But the good man and those with him were saved;" and ever since, on the anniversary of the event, all those who can do so celebrate it by ascending the highest hill in the neighbourhood, and there indulge in kite-flying and other innocent amusements in which the Chinese delight. This legend is good for the Hong Kong High Level Tramway Company, for on this festival each year their resources are taxed to the utmost in carrying passengers to the Peak.

One of the reasons why the southern district is peculiarly the home of native shipbuilding is that timber is always obtainable; China itself is an almost treeless country, but the magnificent woods of the Phillipines, the Straits, and Borneo all find a central market here, and the Chinese, natural mechanics, as they are, have in successive generations of carpenters produced workmen who can handle these timbers better than anyone in the world. To enter into a description of the various woods in use would not convey much information; suffice it to say that hardwood of a specific gravity of about 0.9 is employed for frames, beams, and planking; China fir for small masts and spars and the linings of vessels; teak for frames and plankings; camphor for natural crooks; and Oregon pine for large spars. Junks are seldom copper sheathed; when the bottom gets foul the vessel is beached and careened, and the wood scorched with fire; this kills the *teredo navalis*, the greatest scourge in tropical waters, and also loosens the barnacles and renders scraping easy; a coat of tar is then laid on, and the " docking " is finished.

Oregon pine has come into vogue for planking during late years, but it is recommended only for cheapness, as it is peculiarly susceptible to the attacks of white ants. These pests will consume the whole of the inside of an Oregon pine beam, leaving only a shell, and then depart for fresh fields, while China pine planks contiguous will be found untouched. The white ant will eat any wood, but, like all gourmands, has its preferences, and it is cheaper in the end to use the kinds which are not too high up in its menu. When once a vessel has become infested, the best remedy is to sink her for forty-eight hours,—rather a costly cure, but the only effective one.

Clumsy as junks are in appearance, it is wonderful how easily they are handled; the lateen rig is light and easily controlled, and it is admirable to see the sailor-like way in which a tack is made, the man at the wheel being generally a woman with a baby strapped on to her back, and with a small boy to help run the tiller over. The enormous rudders, when unbalanced, are perforated with diamond-shaped apertures, which reduce the effort of putting " hard over " to a minimum while not much affecting the efficiency in steering. Another feature of the rudder is the provision made for lifting and lowering, so that when a vessel is beached or sailing on light draught the rudder can be adjusted to suit the circumstances.

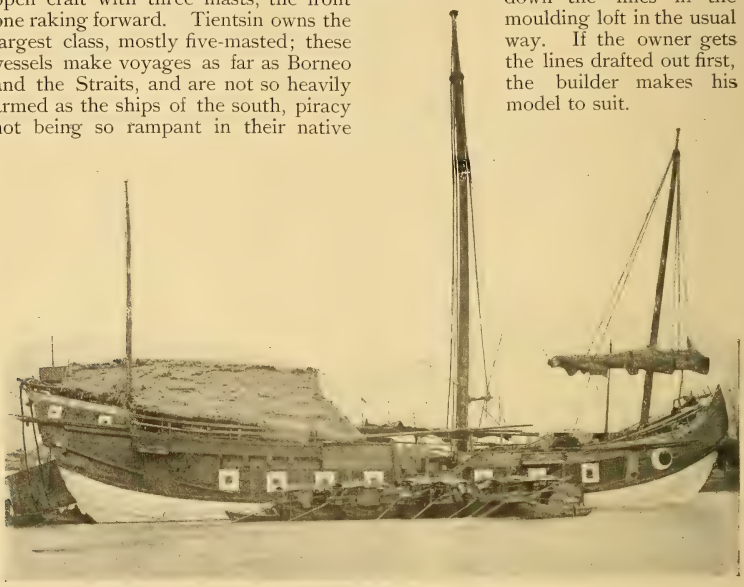
The windlass for hoisting anchors and working cargo is as simple as any device can be; sailors grasp the upright handle, plant one naked foot on the lower one, then turn, using both arms and legs; four men on a windlass will rapidly move heavy weights, but the expenditure of muscular energy is, of course, great. Cannon on deck are very necessary in these days of piracy in Chinese waters, and, unlike those found on the city walls, are generally in working order. The high poop reminds one of the Spanish galleons of the Middle Ages; it is the home of pigs and fowl, as well as of a colony of women and children.

The watertight bulkhead has always been a feature in Chinese naval architecture. It is no uncommon thing to see a junk come into harbour with one end completely gone, mast and everything; there is generally one bulkhead forward and one aft, but sometimes the cargo space is sub-divided also. During the typhoon season these vessels

come to grief in great numbers, as, in spite of their strong construction and skilful handling, they are, on account of their shape, much at the mercy of the elements.

Each district has its peculiarity of build and rig. Ningpo affects a small, open craft with three masts, the front one raking forward. Tientsin owns the largest class, mostly five-masted; these vessels make voyages as far as Borneo and the Straits, and are not so heavily armed as the ships of the south, piracy not being so rampant in their native waters. One feature, common to all, is the eye in the bows. "No got eye, no can see; no can see, no can savvy." Hundreds of miles from land they may be met with, and with the assistance of the eye and the compass, whose needle points south, and the stars and the sun, they mostly reach their destination; and if they fail, it is due to "Bad Joss."

The methods Chinese use in building their craft are pure rule-of-thumb, or, more correctly, old experience. One building yard is renowned for snake boats, another for lorchas, and so on. The keel is laid, frames are set up "allee same before," and the owner's only anxiety is to see that he gets the scantlings agreed upon, the model being left to the builder. When constructing for Europeans, the Chinese builder makes the customary half-model, and submits it for approval; then he lays down the lines in the moulding loft in the usual way. If the owner gets the lines drafted out first, the builder makes his model to suit.



A CHINESE JUNK
"NO GOT EYE, HOW CAN SEE?"

It would be difficult to find another place in the world possessing so many beautiful and powerful steam launches as Hong Kong, and quite three-fourths of these are constructed without European assistance, and often without supervision. Being so well able to build vessels of foreign type suggests the query why the Chinese should continue to build junks? Here, again, is another example of official restrictions cramping natural enterprise.

The shipping cleared out of Hong Kong in 1899 amounted to 27,975 vessels, of which 22,501 were junks; the tonnage was, respectively, 8,563,127

and 1,846,749, the foreign-built vessels averaging 1226 tons each, and the junks 86½ tons. Now, foreign built vessels can trade only to the "open" ports, but there are numberless other centres of trade in China to which junks can ply. These pay customs dues, assessed by the local Hoppo, and varying with his degree of rapacity and the astuteness of the skipper or shipowner. But the dues are invariably higher for vessels of foreign type. Customs passes may be obtained at the port of departure, and are recognised by the officials of the Imperial Maritime Customs, who have no power to levy duties on cargo carried in native bottoms. Likin,—another form of extortion somewhat resembling the octroi in France,—can be negotiated only by experienced native captains in native craft; other vessels may have transit passes, and everything in perfect order, but, somehow, they always meet with obstacles and reverses enough to dishearten the most persevering.

When clearing at the Hong Kong Harbour Office, a junk pays a fee and receives a paper on which are stated the nature of the cargo and the alleged destination, and a recommendation to the crew to succour any distressed seamen they may meet, and to carry no stinkpots. There are no load line regulations, the number of passengers and crew is immaterial, the food question the business of the master, no side lights,—it costs oil to burn them,—no vexatious rules and regulations whatever, and this the Chinaman dearly loves, for then he can economise to his heart's content.

On the rivers, steamboats are permitted to stop only at certain stations, yet passengers will travel twenty miles in a direction opposite to their route in order to catch a steamer, in preference to trusting themselves and their belongings to native craft. Were all disabilities removed, we should soon see the picturesque, but antiquated, junk disappear.

Above Canton there are numbers of stern-wheelers, the wheels being turned by coolies working on treadmills. Wooden chimneys were originally fitted to them, but the travelling peasantry were not to be deceived into thinking that they were steamers; so they were discarded. It is amusing to watch a race between these boats, the coolies, fifteen to twenty to a wheel, bobbing up and down, yelling like demons. Until last year the only type of sternwheeler on this river was that propelled by muscular force; but several shallow-draught screw boats have recently been introduced and accustomed the natives to the use of steam.

For several years the river has been nominally open to foreign trade, but the native authorities succeeded so well in hampering new innovations that it is only recently that any kind of steam vessel managed to pay its way. As the obstacles were gradually removed, the new mode of travelling increased in popularity to such an extent as to encourage a syndicate of three European steamship companies to place on the river a couple of large modern sternwheelers. They are of steel, 168 feet long, 31 feet broad, and 8 feet deep, have accommodations for three classes of passengers, and are fitted throughout with electric light; there is also forced draught for use when driving up against the rapids, extensive cooking arrangements, and everything conducive to comfortable travelling. The appreciation of the Chinese is shown in the fact that these boats became at once the best patronised on the river.

As nearly all the timber used for shipbuilding in China is imported, and as the country possesses illimitable quantities of iron and coal besides other minerals, it is safe to prophesy that the day will come when shipbuilding will be one of the greatest industries of the far East. The natives possess all the qualifications for carrying on such work, and the opposition to opening up the country, disturbing graves of ancestors, etc., comes not so much from the masses as from the classes, who incite the former to acts of violence.

The best smiths, fitters, moulders, and boilermakers from Burmah to Japan are Chinese. In every foreign settlement, Borneo, the Straits, Tonkin, the Phillipines, we find Chinese artisans who

have been trained under European supervision in Hong Kong or Shanghai, and who emigrated to those countries, where their services are always in demand.

All the foreign dockyards and engineering shops make a point of doing nothing but high-class work. Plant is already laid down sufficiently large to deal with vessels of considerable size. Still more is projected, and when the time comes for transpacific liners to be built in China, it will be found that the quality of the work will not be inferior to that of the Clyde.

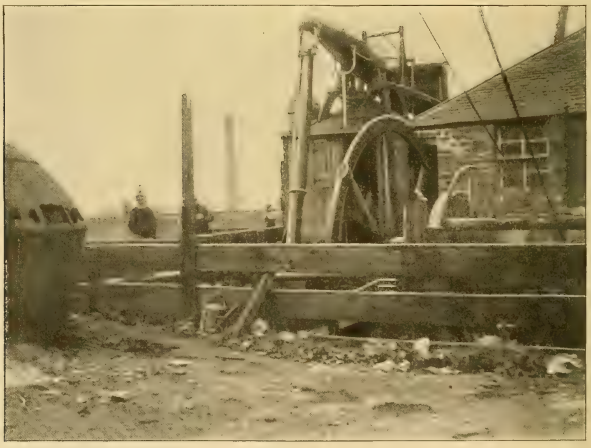
A LIVE MAMMOTH

THE OLDEST STEAM-ENGINE IN ACTIVE SERVICE

By Professor William Cawthorne Unwin

IN the scattered drift of Northern Europe are found the bones and teeth of a great beast which must have represented to paleolithic tribes the extremest development of mechanical force. In the frozen cliffs of Siberia more than one of these great beasts has been discovered, with flesh and hair still undecayed. It is not impossible, however unlikely, that a live mammoth might yet be found roaming in the scarcely explored regions bordering the Arctic Sea. Were it so, what an interest would be excited, not in scientific circles only!

In the eighteenth century the greatest achievement of mechanical engineering was the atmospheric or Newcomen engine. It played a great part in the development of mining, on which the industrial progress of Great Britain depended. But late in the eighteenth century it was supplanted by the much more economical engine of Watt, and



A NEWCOMEN ENGINE AT RUTHERGLEN, NEAR GLASGOW, BUILT IN 1809

disappeared, like the mammoth. For a time one or two old Newcomen engines continued working in out-of-the-way mining districts, but their clumsy size and inadaptability to modern conditions of life doomed them to rapid extinction. Here and there in mining districts one has come upon the remains of old atmospheric engines slowly decaying, like the Siberian mammoths, left where they ceased to labour, chiefly because they were too big to make it worth while to cart them away.

Last summer, however, much to one's surprise, while at the Glasgow Congress of Engineering, and directed by the excellent hand-book prepared for the guidance of members of the Congress, a real live Newcomen engine was discovered at a colliery at Rutherglen, near Glasgow. It is almost certainly the oldest engine now at work. Though possibly it is well known to Northern engineers, it may be useful to put on record some account of it for others. It is really a quite remarkable case of the survival of the unfittest.

A few years ago an engine of James Watt's manufacture, with sun and planet wheel complete, was taken down at a London brewery. It had been continuously working for 102 years, and was not at all decrepit when dismounted. It now forms an archæological exhibit in the museum of Sydney University.

ANOTHER VIEW

But this engine, though interesting and of about the same age as the Glasgow Newcomen, was of a comparatively modern type. It did not represent an extinct race.

The Newcomen engine at Farme Colliery, Rutherglen, was built in 1809, and has worked continuously to the present time. As it was constructed long after Watt's invention of the separate condenser, it may, perhaps, be inferred that one object in its design was to escape payment of royalty. Curiously enough, unlike all other Newcomen engines of which there is record, it is a winding, not a pumping, engine. The cylinder is of pure Newcomen type, but there is a modified Watt parallel motion with the radius bar above the beam, and a crank and fly-wheel of comparatively modern type.

The cylinder is 3½ feet in diameter, and the stroke 6 feet. It takes about thirty-five seconds to raise coal from the bottom of the pit to the ground level.

The cylinder was never bored, but it has now a beautiful internal surface, having worn out probably a thousand packings. The piston is packed with hemp gasket, and carries a layer of water on top, which makes it quite steam tight. There is no automatic valve gear. A single handle, worked by a man, opens alternately the steam and injection valves. There is no air pump. Gravity and the pressure of the incoming steam drive out the condensed steam and injection water through a flap foot-valve. It is stated that except brasses and one or two spur wheels, broken by accident, no important part of the engine has been renewed since it was built.

The beam is about 17 feet long and the fly-wheel is 15 feet in diameter. There is a feed-pump worked from the beam. The latter is carried on a masonry pier. The engine works quite smoothly and well, and, strange as it may seem, it is probably, for the intermittent work it is doing, not so extravagantly wasteful as might be supposed.

Current Topics

THE general public, interested in a thousand and one things, soon ceases to regard any invention as a novelty after it has, however quickly, come into general use, even though it may have worked a revolution in the particular field which it has entered and may have practically usurped. The same public is usually more interested in obtaining a reduction in the price of the new commodity than in its further technical development. A case in point is the incandescent electric lamp. The users of such lamps, as a rule, pay little or no attention to the technical features of durability or efficiency, and any mechanical improvements in the lamp which they may happen to observe are received as a matter of course. Indeed, it may be said with considerable truth that many of the largest purchasers of these lamps have learned much that they know concerning lamp merits or demerits from rival manufacturers, who, in their anxiety to capture trade, frequently impart information, and sometimes misinformation, concerning the inefficiency of carbon filament lamps in general, of which otherwise the trade might have remained forever blissfully ignorant. Of course, the foregoing does not apply in all cases, for it is well recognised by not a few of the managers of central stations that a low-efficiency of lamps means a greater consumption of electrical energy for a given amount of illumination, and proportionate dissatisfaction to consumers, and in such stations a well-equipped

lamp-testing department is considered an indispensable requisite.

As a matter of fact, there has been but little improvement in the efficiency of the carbon filament lamp during the past ten years. In that time, it is true, a number of mechanical improvements have been worked out, and commercially practicable lamps for 200-volt circuits have been placed on the market, broadening the field of usefulness of the lamp; but its efficiency and durability are probably reduced rather than enhanced by the increased electrical pressure. The average efficiency of the carbon filament lamp remains at from four to five watts per candle power, and its average life is less than 400 hours at this mean efficiency. This is the equivalent of 9.3 to 11.7 16-candle-power lamps per horse-power,—a low efficiency, of course, but the exceeding simplicity of lighting and extinguishing this lamp, and the ease of effecting renewals, in which it is much superior to the Welsbach gas lamp, together with its other advantages as an illuminant over gas, have been its chief popularising features. Inventors have, however, long been seeking to devise an incandescent electric lamp of higher efficiency than that possessed by the carbon filament lamp, and in this some of them appear to have been successful, but at what cost as regards simplicity, reliability, colour of light, and economy remains to be demonstrated.

One of these improved lamps, known as the Crawford-Voelker, employs a filament made of carbon and some of the rare earths, enclosed in a bulb after the manner of the carbon filament lamp. A carbide of titanium filament has thus far given the most successful results, but a number of other rare earths have also been utilised in the experiments along this line. With this filament an efficiency of about 2.8 watts per candle power has been obtained, which is equal to about seventeen 16-candle-power lamps per horse-power. It is claimed for this lamp that it maintains a high efficiency for a much longer period than the ordinary carbon filament lamp, and is at least equally as durable as the latter.

Another incandescent light, which is now well known, is the Nernst lamp. This lamp employs a filament, termed the "glower," compounded also of an oxide of the rare earths, which, at a low or normal temperature, has a high electrical resistance, but which, like certain combinations of oxides, such as magnesia with porcelain, becomes a good conductor of electricity, and also becomes highly incandescent at high temperatures. In order to utilise such a filament as an incandescent electric lamp, it is obviously necessary to provide means by which the temperature of the filament may be raised to such a point that electric current will pass through it, after which the current itself maintains the temperature and raises it to the required degree to produce incandescence. A lighted match applied to the filament will bring about the desired result, but in practice a small coil of platinum wire is arranged in the socket of the lamp in such a position that the turning on of the current raises the temperature of the wire, which, in turn, heats the filament. This lamp has an efficiency of 1.5 watts per candle-power,—about thirty-one 16-candle-power lamps to the horse-power,—and is employed to a considerable extent in Continental Europe. It is said to have a life of about 800 hours with an alternating current, but much less with a direct current, perhaps 400 hours, an electrolytic action in the latter case having a detrimental effect. The colour of the light is very agreeable. But its cost must obviously be greater than that of the carbon filament lamp.

One inventor, working upon quite different lines, has brought out an in-

candescent lamp which has shown very high efficiency. This lamp, the Cooper-Hewitt, employs mercury vapour in a suitable glass tube, or bulb, instead of a filament, through which an electric current is caused to pass. The current is led into the tube by wires sealed in each end, a small quantity of mercury being placed at one end of the tube. It is, however, found that a much higher electromotive force is required to start the current through this tube than is necessary to maintain the normal operating current after it is started. On this account a special device to obtain a momentary high electromotive force is requisite. The starting may, however, be facilitated by warming the tube by means of a Bunsen burner, by employing a vapour of the sulphide of mercury, or in other ways. Tests of one of these lamps, a tube 54 inches long by 1½ inches in diameter, showed it to have a mean efficiency of about 0.55 watts per candle-power, which is equal to about 85 16-candle-power lamps per horse-power. When the current is passing through the tube the vapour glows with an intensely bright light, which, however, unfortunately, is very poor in red rays, and hence everything red exposed to it,—the lips, the ears, the cheeks,—takes on a blue-black colour. The result of this is that a ghastly, if not a ghostly, effect is produced in a crowded room or hall lighted by these tubes. This effect is removed by the presence of a number of ordinary incandescent electric lights which supply the essential red rays. The inventer, it is understood, is at work upon this feature of the light, and will, doubtless, remedy it. He has already ascertained that a mixture of mercury vapour and nitrogen produces a rich, soft light. The light emitted by the mercury vapour lamp is evidently quite rich in actinic rays, as excellent photographs have been taken with it with an exposure of but a few seconds; indeed, the light appears to resemble daylight in this respect.

While, therefore, these various types of improved incandescent lamps are very interesting, and will, no doubt, find useful fields, it is worthy of note that the plain carbon filament, with its comparatively and admittedly low intrinsic illuminating qualities, continues to be manufactured by the dozens of millions annually, at a price which would seemingly, by its cheapness, bar out competition for some time to come, its cost being less than that of a good Welsbach or Auer mantle.

Paraffine moulding boards, which were mentioned in connection with moulding machines in the article entitled "A Modern Foundry," in the February number of this magazine, call for a word or two of explanation which may be interesting to some. Moulding boards, which are really the mounts for the pattern, are ordinarily made of wood, which may be dry in the morning when the work is started, but which absorb more or less moisture during the day, so that the moulds taken from the machine in the afternoon and those made during the morning may differ. According to Mr. A. L. Rohrer, the author of the article referred to, the practice of the General Electric Company, of Schenectady, N. Y., is to make the boards of seasoned hardwood, and to boil them in paraffine long enough to become thoroughly impregnated. The paraffine not only prevents the absorption of moisture by the boards, so that the castings are very uniform, no matter at what time of the day the moulds are made, but it also makes the boards smooth and easily freed from sand, so that no hand touching is necessary. The paraffine boiling is one of those tricks of the trade which is simple enough, but has much to do with the success of the machines.

American electric tramway practice is so omnipresent, says Mr. E. Kilburn Scott, in a recent issue of the London *Electrical Engineer*, that in visiting various countries thousands of miles from one another one finds the same apparatus, the same types of trolley wire

fittings, etc., to a degree which is almost monotonous. There is one feature of car equipment, however, in which the Continent has refused to follow America, and that is in the current-collecting trolley. It is quite a relief to go to Germany and find the fishing-rod trolley pole almost entirely displaced by the Siemens bow trolley. It may be interesting to consider for a moment the advantages and disadvantages of collecting current by means of a bow contact and by means of a wheel. First and foremost, the bow trolley has the great feature that it is impossible for it to jump the trolley wire. The number of accidents and stoppages of traffic that can be traced to the fishing-rod pattern of trolley jumping the wires are legion. It is quite the commonest accident that occurs on a tramway system, and it is just the one accident that in the very nature of things cannot occur when a bow trolley is employed. With the trolley pole there have been cases of injury to passengers through the wheel and its bracket becoming detached, either by working loose in the ordinary way or receiving a blow against a space wire or bracket arm due to the pole jumping the wire. Now, with a bow trolley there is nothing to get loose,—that is to say, there are none of the pins, bolts, etc., which go to make up a trolley head. Many of the accidents which occur from time to time on account of trolley wires breaking are traceable to the wrenching and hammering which the overhead fittings receive from the trolley wheel. The actual wearing surface of a bow with the trolley wire is very considerable, and is always changing, so that there are practically no renewals to be made. Once the bow trolley is fixed, there it remains for years without any alteration, whereas in the case of the pole the trolley wheel must be renewed at frequent intervals.

As the rubbing contact of a bow is entirely on the under side of the wire, the overhead fittings may be very simple, and it is possible to pass over switches and go round corners, etc., at a good speed. With the trolley pole, on the other hand, the wheel wraps round the wire to a certain extent, and both switches and frogs,—in fact, all the trolley wire attachments,—have to be specially designed to meet this condition, which is of a wrenching character. With regard to noise, the writer's impression is that the bow gives much less noise,—at any rate, the hissing noise of a bow is always the same,—whereas with the wearing of the wheel it becomes more and more noisy. Noise is not noticeable in a busy street, but along a suburban road, with residences on each side, it is a point requiring consideration. In changing direction at termini, the height of a trolley wire can be arranged so that the bow will adjust its rake automatically for the return journey. With the trolley pole, on the other hand, the guard must reverse the rake and fish about until he gets the wheel on the wire; at a suburban terminus on a dark night this is not always easy. In the case of a block or breakdown the bow trolley is much more handy, as the car can run quite readily in either direction, and thus leave the guard free to attend to other duties. This turning round of the trolley pole to change the direction is a great nuisance, in that suitable provision has to be arranged (in some cases contacts) in the trolley standard. In the case of the bow trolley, with its movement in one place only, there is no trouble whatever. Regarding the picking up of current, it is a matter of interest to know that the result of the experiments in Germany on high-speed traction has shown that the bow is far and away the best method of collecting current. It will collect larger amounts of current and admit of much higher speeds than a wheel contact, and the spring of the bow itself appears to present important advantages over the more rigid wheel construction.

A NOVEL method of using electric power, and one which proved economical as well, was recently told of by a

Californian correspondent of *The Engineer*. The plant, which is installed at a mine, comprises two horizontal return-tubular boilers, 54 inches in diameter by 16 feet long, one 12 in. × 12 in. double-cylinder hoisting engine, a 14 in. × 22 in. duplex air compressor, and a smaller steam-engine for driving a rock breaker and ventilating fan. The fuel is crude oil, presumably the product of the Southern California wells. The hoisting and rock-breaker engines are steam driven, while a 150 horse-power induction motor drives the compressor, which furnishes air at eighty pounds pressure for the rock drills. The air compressor was formerly considerably underloaded for the greater part of the time, being worked about 50 per cent. of its capacity.

It appears that the electric company will not furnish at this point less than 200 ampères, at a potential of 600 volts, at anything approaching a reasonable price, and, inasmuch as this amount of current must be paid for whether used or not, it was determined to put it to some use with the present apparatus. The motor and air compressor are now worked to their full capacity, and the excess of air is forced into the steam boiler. At times when the load on the hoisting and breaker engines is very light the compressed air becomes the only motive fluid, the consumption of oil under the boiler falling almost to zero, the boiler merely serving as a heater for the compressed air, while with the usual load the steam is employed to make up the deficiency. The saving in oil under the average full load is claimed to be 250 gallons in twenty-four hours, which amounts to about $10 per day. The greatest difficulty experienced in thus utilising the compressed air is said to be in securing proper lubrication of the engine cylinders. The steam is exceedingly dry, and when the load is reduced beyond a certain amount the quantity of steam furnished is insufficient to provide the required amount of condensation for the lubricators. It is stated in this connection, however, that it is thought that this difficulty can readily be overcome by employing force-feed lubricators, the use of which is anticipated should the existing conditions continue for any great length of time.

One line of manufacture in which the system of interchangeability of parts has been carried into excellent effect in the United States is that of field and opera glasses. With the several makes of splendid instruments of this class turned out in Germany, which has for many years led the world in this specialty, it has been vexatious to find that each little screw even was fitted only for its particular place and would go nowhere else, and was accordingly supplied with some reference mark or number so that, if removed for any reason, it could be again returned to its original position. With these German instruments also there has been the standing injunction that for repairs they must be returned to the makers, and the possible delays and consequent annoyances from this cause have been unpleasant to contemplate. In the United States interchangeable work has so cheapened the cost of manufacture that corresponding glasses, of the highest quality, are now made and sold there at the same prices that are charged for similar instruments in Berlin, and they have the advantage besides that all their parts can be duplicated at short notice, and are certain to fit properly in their intended places.

The interesting fact is noted, in a recent United States consular report from Rouen, that automobilism, directly or indirectly, maintains more people in France than any other industry. All the factories have tripled their output during the last three years, and manufacturers formerly making cycles now produce automobiles. At first, Paris was the only city where automobiles were made, but now Lyons, Bordeaux, Marseilles, Lille, St. Étienne, Nantes, and Rouen have factories to supply local

demands. By reckoning all the workmen in the various branches that are benefited by the automobile industry, a total is obtained of nearly 200,000 persons dependent upon it. The general consensus of opinion among the French makers is that the big machine is a thing of the past because of the restrictions upon speed in all. The demand is growing for a strong, light, and comfortable machine of moderate speed for general use.

BION JOSEPH ARNOLD

A BIOGRAPHICAL SKETCH

By John B. O'Hara

THE career of an eminent engineer, who is just now occupying a conspicuous position because of his selection by a big corporation to take charge of an important undertaking of a semi-public character, presents an interesting subject for a biographical sketch, and, at the same time, affords an opportunity for reflection upon the elements that are essential in gaining prominence in this profession and recognition as an authority on engineering subjects. Natural ability of a high order is, of course, absolutely necessary, and this must be supplemented by habits of industry and perseverance, for no matter how great the original qualification may be, it will not avail unless it is carefully trained, properly directed, judiciously governed, and fortified by practical experience, which alone can give it the conservatism and confidence of mature judgment.

Mr. Bion Joseph Arnold, of Chicago, the subject of this sketch, possesses these characteristics in a marked degree. He is one of the foremost advocates of modern ideas and methods that have come to be recognised as improvements of the highest order. International reputation was gained by him as designer and builder of the Intramural Railway power plant at the World's Fair at Chicago in 1893, which embodied many new ideas and may be said to have formed the basis for subsequent practice in this direction. The adoption of direct-connected units for this power station was an important step, and it did much to popularise this innovation, as it brought it prominently before the engineering profession in greater numbers than could be reached through any other equally effective agency.

Realising that independent direct-connected sets would be at a disadvantage under many conditions, Mr. Arnold evolved the idea of combining several direct-connected machines in such relationship to one another that, by putting a coupling between each engine and generator and providing an auxiliary shaft, every generator would be available from more than one engine, though normally direct-connected to its own engine. The practicability of the system has been demonstrated in many of the largest plants that have been installed during the last few years.

This improvement led to others, one of which was of considerable magnitude, and it opened up a new field. In practice it is often desirable to throw a dynamo out of use, and, at the same time, to substitute another in its place without stopping the driving engine so that there will be no interruption in the service. As this was a very important point in the system advocated by Mr. Arnold and the ordinary friction clutch was not deemed sufficiently reliable, he invented a magnetic clutch, which has been made in several sizes, ranging from 50 to 3000 horse-power in capacity, for the stations

in which his system is in use, and for many other applications as well.

Mr. Arnold proved a powerful friend of the storage battery in the days when to speak a word in its favour was equivalent to risking one's professional reputation. Men of less positive character did not openly espouse its cause and thus jeopardise their influence even when they did not strongly oppose it, but Mr. Arnold recommended it wherever he deemed it available, encouraged its development, and proved his faith in it by investing his entire means in its manufacture, and he has since not only enjoyed financial success in this field, but has had the satisfaction of seeing his views generally adopted. He advised the adoption of the sub-station rotary converter storage-battery system for the Chicago & Milwaukee Electric Railway, and, in order to demonstrate the merits of the system and overcome the objections raised against it, he took the contract for building and equipping the entire road on the lines he had laid down as the consulting engineer, guaranteeing the efficiency and operation of the completed system. The equipment effected, as he had held, a great economy in first cost and operating expense over any then in vogue, and the successful operation of this road was followed by a general adoption of the system.

As consulting engineer for the Chicago Board of Trade he designed a system and built a plant in which all the power used in the building was generated in one set of steam cylinders and transmitted electrically to the several elevators and other power-consuming machines, using electric elevators, storage batteries, and electric motors in place of numerous small steam-engines, line shafts and rope drives. The work was carried on in spite of bitter opposition, and resulted in greatly reducing the operating expenses. This at once assured for it respectful consideration, and it is now recognised as standard practice in office buildings.

Mr. Arnold is in demand as a special lecturer on engineering subjects. He has in this capacity addressed the engineering students of the University of Illinois, the University of Michigan, and Purdue University, and, in 1897, he delivered at the University of Nebraska a course of ten lectures on "The Design and Construction of Electric Power Plants." The faculty of the institution recognised his work by conferring the honorary degree of E. E. upon him. A gold medal was awarded him by the Trans-Mississippi Exposition at Omaha in 1898 for a personal exhibit. He showed some of the crude models and devices which he had built at Ashland many years ago, alongside of the drawings of his later engineering triumphs.

Mr. Arnold has been a careful student and an earnest investigator of electrical phenomena, and he has placed the results of his experiments at the command of his fellow workers. Technical electrical literature has been enriched by his contributions in the form of papers and discussions before the principal engineering societies of which he is a member. He was a representative of the American Institute of Electrical Engineers, the foremost body in this profession, at the International Electrical Congress at the Paris Exposition of 1900, and took advantage of the opportunity afforded by this trip to visit the principal electrical works and electrical installations in Great Britain and on the continent of Europe, spending the entire summer in careful study of European practice.

Mr. Arnold's early career is typical of America, and shows the possibilities at the command of young men of ability, perseverance, and strength of character. Early associations, training, and family influence all tended toward preparing him for a career entirely different from that which he selected, and he may be said to have been the architect, as well as the builder, of his fortune. His father, who was a lawyer and a member of the territorial Legislature of Nebraska which framed its constitution just prior to its admission into the Union, very naturally wished his son to adopt the legal profession, but the boy's natural desire for mechanical work constantly directed his mind and eventually determined his course. This is especially

remarkable in view of the fact that there was nothing about his early surroundings to inspire mechanical genius. There was not a mile of railroad in Nebraska at the time, and neither machine shops nor manufacturing establishments were in the vicinity to awaken the lad's interest in work of this kind. Yet he showed the instinct of a mechanic even in early boyhood by making many crude models of farm implements. At twelve years of age he built a steam-engine, at fourteen a bicycle, and at eighteen a small locomotive which was a complete operating engine in every respect. At the age of nineteen he left his home to seek instruction in the East, where he could be in contact with engineering work and the men engaged in it, but without a friend or even an acquaintance in his chosen field.

Unlike most precocious youths, Mr. Arnold's early efforts did not exhaust his capacity, but, contrary to the general rule, were really indicative of the possibilities awaiting development with maturity. Passing over an educational period of six years, we find him at twenty-five chief designer of a large iron works; at twenty-seven, mechanical engineer for a steam railroad; and at thirty, consulting engineer for a large electrical manufacturing company; at thirty-one, designer of the Intramural Railway power plant at the Chicago World's Fair; at thirty-two, an independent engineer; at thirty-three, developing and successfully exploiting a commercial storage battery; at thirty-four, introducing the magnetic clutch; at thirty-six, successfully demonstrating the practicability of long-distance electric railroading by equipping the Chicago & Milwaukee Electric Railway; at thirty-nine, engaged in equipping sixty miles of railroad under a new system of his own invention; and at the present time consulting electrical engineer for several steam railway companies, among them the Chicago, Burlington & Quincy upon the equipment of one of its mountain lines, and at the same time, in a like capacity, engaged in devising a feasible plan for electrically operating the trains of the New York Central Railroad in and out of New York,—a problem of great difficulty and far-reaching importance.

Brief reference to the preparatory course pursued by Mr. Arnold, which fitted him for this work, will be interesting at this point. His family had moved, in 1864, from Grand Rapids, Mich., where he was born in 1861, to Ashland, Neb., and he received his early education in the public schools of the latter town, commencing his course in engineering at the University of Nebraska in 1879. After remaining there one year he entered the scientific course at Hillsdale College, Mich., from which institution he received the degree of B. S. in 1884, taking a mathematical prize for a six years' course, and three years later the degree of M. S. In 1889 the same institution conferred upon him the honorary degree of M. Ph. for engineering work done subsequent to his graduation. It was at this time, in April, 1889, that Mr. Arnold finished a post-graduate course in electrical engineering at Cornell University, and, in June, 1897, the degree of E. E. was conferred upon him by the University of Nebraska.

Mr. Arnold's early efforts were directed, even in his schoolboy days, to building something, and his work in this line extended to the construction of small engines, electric motors, and other mechanical appliances. It has already been mentioned that at fourteen years of age he had made a bicycle, and it should be added that he had never seen a bicycle, and was guided entirely in this undertaking by an advertising cut of a high-wheel machine published in a juvenile paper. His bicycle was the first seen in the State of Nebraska. At eighteen he built the small railroad locomotive previously mentioned, with such tools as could be found in a country blacksmith shop. Prior to this he had constructed stationary toy engines, using crude materials.

When fifteen years of age, he began to spend his summers running traction engines, doing threshing work on Western farms, and thus acquired a certain amount of skill in handling machinery.

He spent his summer vacations when in college travelling as an engine expert for engine-building companies, and he spent one summer in the field with a civil engineering party. On graduating, in 1884, in order to acquire a business experience, he acted as general agent for an engine company for two years, and then engaged with the Edward P. Allis Company, of Milwaukee, as a draughtsman, leaving that company to become chief designer for the Iowa Iron Works, of Dubuque. Subsequently he engaged with the Chicago, St. Paul & Kansas City Railway Company, now the Chicago Great Western, as a civil engineer, and when the road was turned over to the operating department Mr. Arnold acted as mechanical engineer, a position which he resigned in 1888 to take the post-graduate course at Cornell University.

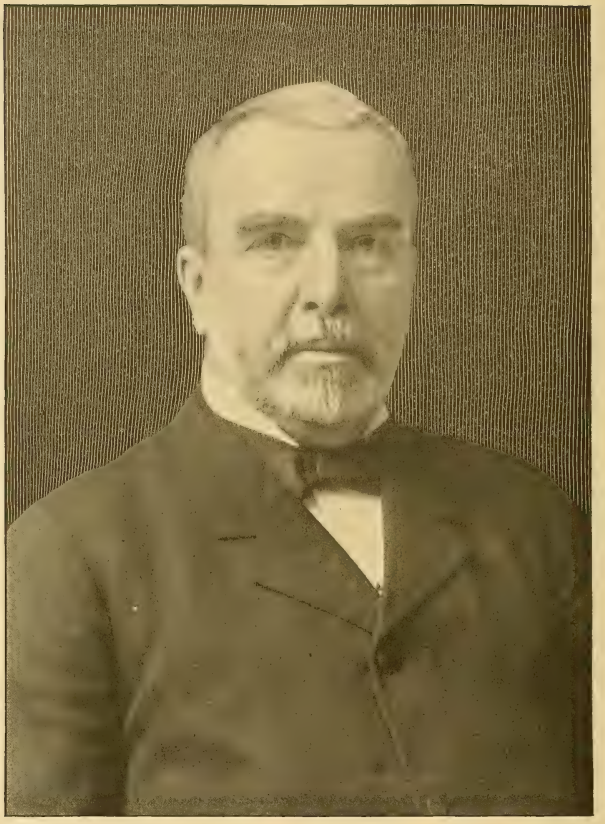
On leaving Cornell he engaged with the Thomson-Houston Electric Company, taking charge of the St. Louis office as engineer and agent. Two years later he was appointed consulting engineer for the Chicago office of the same company, a position which he continued to hold after the consolidation of the Thomson-Houston and Edison General Electric companies into the General Electric Company. He next established himself as an independent consulting electrical engineer, and, since 1893, has devoted his attention to the design and construction of many electric properties throughout the United States and Mexico, and to perfecting inventions and improvements which have given him additional reputation.

His success has been such that he now maintains offices in Chicago and New York, and has become largely interested in industries allied to his calling. He is president and technical director of the Arnold Electric Power Station Company, a corporation operating under his patents, and which has been especially successful in designing and constructing large electric railway and power properties. He is also president of the Kenosha, Wis., Street Railway Company, and vice-president of the Kentucky Western Railway Company.

One of Mr. Arnold's characteristics seems to be to keep in advance of his profession. His solution of engineering problems, therefore, has often been carried out against much opposition. As he demonstrated the success of one after another, adverse criticism turned into well-merited praise, and more than once he has had the pleasure of seeing his work become commonly accepted practice.

An idea of the character of the man is furnished in the fact that on three distinct occasions he withdrew from profitable, and what were assured to him as permanent, positions at considerable financial loss in order to take up another line of work which he considered necessary for his ultimate success. As a result he has gained a broad and varied engineering experience of great value in his professional work. His career as a student, whose hours of relaxation were devoted to the practical application of the knowledge gained to enable him to earn a livelihood, was followed by gratifying experience as a lecturer in the scenes of his early studies. Viewed in this light, the life of Mr. Arnold presents many sharp contrasts, but they are all relieved by the brilliant setting of ultimate success achieved at such an unusually early period, and the respect and esteem in which he is held by his fellow workers.

Mr. Arnold, while not a clubman, is a member of several organisations, principally of an educational character, however. He is a member, for example, of the American Institute of Electrical Engineers, and has served as manager of that body as well as one of its five representatives at the International Electrical Congress in Paris. He is a trustee of the Western Society of Engineers, and he was one of the charter members and first directors of the Technical Club, of Chicago. He is also a member of the Union League Club, of Chicago; of the American Association for the Advancement of Science; of the American Society for the Promotion of Engineering Education; of the board of governors of the Chicago Automobile Club, and of the Transportation Club, of New York.



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PRESIDENT OF THE AMERICAN LOCOMOTIVE COMPANY

SEE PAGE 519

CASSIER'S MAGAZINE

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APR 2 1902
PATENT OFFICE

ELECTRICITY IN GREECE

By Frank W. Jackson, Patras

IN NATIONAL COSTUME

THE construction of a thoroughly modern electric street railway system, the first of the kind in the Levant, stamps Greece as more progressive than her immediate neighbours, European or Asiatic. The consolidation of electrical power sufficient to light four cities, run street and suburban railway systems, and furnish motive power to the greatest manufacturing district of the kingdom entitles her to a place, and a prominent one at that, among progressive nations. The former is a fact, rounded out and complete, and is the boast of Patras, the centre of the electric district of Greece; the latter is equally assured, and lacks only the time necessary for its completion to be the greater boast of Athens and the plain of Attica. The two combined justify some attempt to set forth the conditions and surroundings amid which these enterprises are developing.

It may savour a little of the paradoxical for this land of Greece, which in its earlier days was a synonym for poetry and song, to be devoting its energies to the prosaic round of practical and material development; but the legitimate heirs of an energy which made poets, philosophers, and statesmen whom the world delights and will ever delight to honour, could not consistently remain inactive amid the invincible physical forces which are playing a part so important in the successive arrangement of nations. Neither could they be expected to take no part in properly directing these same forces which so easily may cause the great to sit humbly at the feet of the small; and the rapid progress made in recent years along almost every line, coupled with the tenacious purpose of unearthing and preserving and restoring the evidences of a former greatness, are alike commendable and noteworthy.

It is not the purpose of this article to deal minutely with the technical details of these electrical enterprises. What is aimed at is a general survey of the conditions under which these progressive elements are rapidly unfolding themselves and a reasonable conjecture of future possibilities, which may have some interest and a measure of importance to the general reader. And at this point the writer takes the opportunity of acknowledging his indebtedness to the Greek Electric Company for the right to make public such facts as are contained herein, and to Mr. Louis Nicolaides, of Athens, and Mr. S. Londas, of Patras, for valuable assistance in the collection of data; and, fur-

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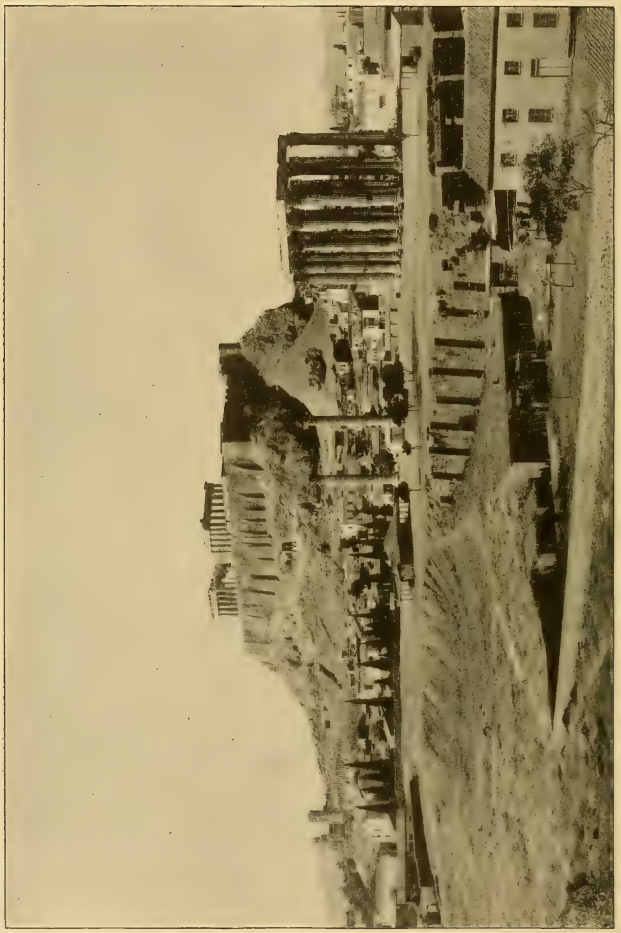


THE ACROPOLIS AT ATHENS, WITH THE TEMPLE OF THESEUS AT THE RIGHT, WITHIN SIGHT OF THE NEW ELECTRIC PLANT

thermore, of offering a single word of apology for some of the accompanying illustrations, which were taken under conditions exotic to the photographic art.

The history of electricity in Greece began about fifteen years ago with the introduction at Athens of a few dynamos which supplied incandescent light for the royal palace, the university, and a few other public buildings. Shortly afterwards, just how long no one seems to know, one or two dynamos were brought into use for street lighting purposes, lighting principally Stadium street, the largest and most popular thoroughfare in the city. From time to time this number was added to until a total of nine dynamos were in use, furnishing light to most of the principal streets and squares, and for a few residences of the wealthier class.

In the meantime, a company was organised for general lighting purposes, but the tariff for light was too high to make it popular even with the well-to-do, and a second company entered the field as competitor. Neither of the companies, however, was sufficiently strong to materially change the conditions, and electric lighting remained practically, as it had been, a convenience for the very wealthy, a luxury for the well-to-do, but a necessity to none. In short, it remained for the Greek Electric Company, of the Thomson-Houston system, organised in 1898, to combine the scattered elements into one organisation sufficiently strong to resist the fluctuating conditions which, in Greece, make the existence of small companies precarious, and to bring electricity for lighting purposes into general and popular use and at fairly reasonable prices. To-day,

SHOWING THE CITIES NOW LIGHTED, OR SOON TO BE LIGHTED, ELECTRICALLY

A CONSTRUCTION VIEW OF THE ELECTRIC PLANT AT NEW PHALERON

STRINGING TROLLEY WIRES AT PATRAS

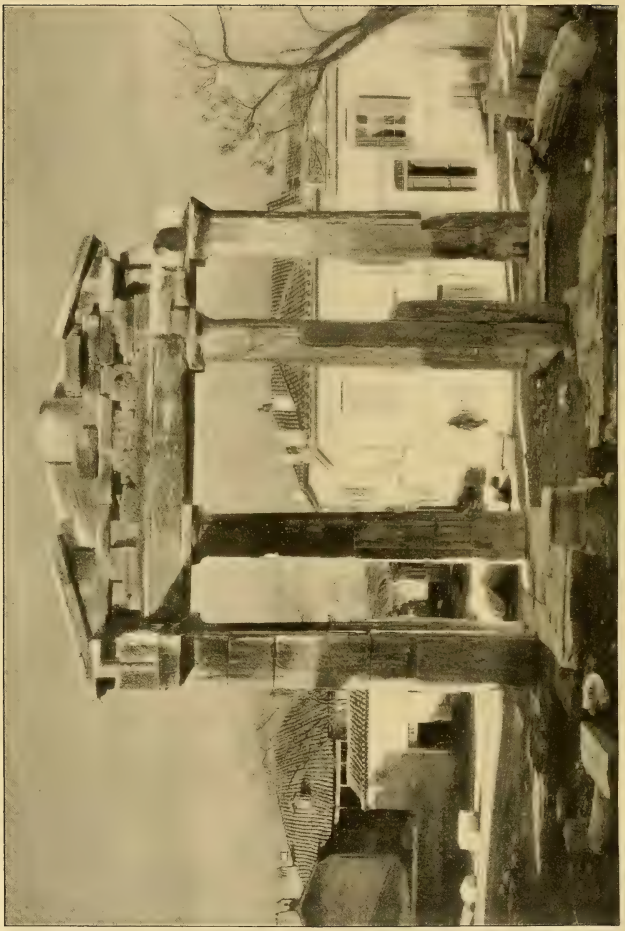
through the expansive methods of the above-mentioned company, every Greek city of any pretentious size has electric service, or the prospects of it, and the few which are yet under the *régime* of gaslight will probably remain so only until the expiration of existing contracts.

The problems which confronted all such enterprises a decade or more ago and rendered prices exorbitant still confront them. Greece has neither gas nor oil for lighting purposes, little or no coal of a steaming quality, and, so far, has not succeeded in harnessing any water-power of reasonable force. While this may yet be accomplished, the time when Nature will make up for this lack of stored energy is too far in the future to warrant the building of fantastic hopes, and the working out of the question of the immediate present is all-important. The solution seems to lie in the centralisation of power at a minimum expenditure, and along this line the Greek Electric Company is now working, having under construction at New Phaleron, near Athens, the largest electrical establishment in the East, and one of the largest in all Europe.

BACK FROM AN INSPECTION TRIP

Before entering upon the details of this enterprise it may be well to give some detailed idea of the extent to which electricity has already been introduced into the country. The following cities are lighted, or are soon to be lighted, by electricity,—Athens, Phaleron, old and new, Cephisia, Calamata, Syra, Zante, Argostoli, and Chalcis, the last four being the principal cities of the islands adjacent, and the last one, Chalcis, capital of the large island of Euboea, having recently celebrated the opening of its electric plant with much ceremony. Patras, the second largest city of the kingdom, is without electricity for lighting purposes, and is likely to remain so for some time to come, since the present contract of the gas company, which owns one of the most modern plants of its kind in the south of Europe, and has also the sole right to introduce electricity, does not expire for forty years. Without entering into particulars concerning the various smaller establishments, which are practically operated on identical lines and controlled by one company, it is enough to say that the light is not of a superior quality. The old dynamos from Athens are serving their second term in many of these less important centres, and while they have improved neither with age nor with change of location, the people nevertheless prefer these old machines and their no longer first-class service to gas or candle light.

Of Athens, however, the occasion may be thought to require something more definite. The electric plant of the city, which is only a mite compared with the



THE OLD MARKET PLACE AT ATHENS

one now building at Phaleron, has a dynamo capacity of 500 kilowatts. This is divided into five groups of 100 kilowatts each, and the current is distributed through the city by the three-wire system. There are now installed in the city 40,000 incandescent lamps of ten-candle power each and 260 arc lights, while power is also supplied to a number of electric motors and to a storage battery. For a city of the goodly size of Athens this light is scarcely representative, but it must be borne in mind that gas also is extensively used for lighting purposes,—very largely in the homes of the middle classes, because it is much cheaper, and largely also for street and public lighting,—while the poorer quarters of the city still cling, for the most part, to the light of their forefathers,—the tallow candle. The Piræus, so closely connected with the life of the city that it must be spoken of as a part of it, is not lighted from the central station at Athens, but has a plant of its own, a small one of 150 horse-power, with two dynamos of 100 kilowatts each. Only thirty-five arc lamps are at present in use at the Piræus, but this number is soon to be increased by an additional 100 for port lighting.

It is not the case at present, much as one might be tempted to say it of such a beautiful city, that the lighting is altogether satisfactory in quality. The arc lamps are very good, but the incandescent lights are of small candle-power and dull, and the deficiency must be met by installing a larger number of lights at increased expense. In one thing, however, Athens leads the majority of cities wherever located, for she protects her citizens with marked care from coming in contact with more electricity than is usually considered good for men. In the business centre of the city all electric wires are underground, and elsewhere they are strung upon poles which rise 50 or 60 feet in the air,—in some other cities even higher,—so that they might easily be taken for flag-poles raised during campaign enthusiasm. And so effective have these means proved themselves to be that since the installation of electricity in the city there has not been a single case of fatal accident. For another city this would be a remarkable record; for Athens it is merely what is expected. Greece, as a whole, is renowned for the care she takes of her few millions of people. Her tramcars are rarely known to run people down; her

THE STEAM TRAMWAY

TEMPLE OF VICTORY AT ATHENS

railways are obliged to skirt the city limits, or, if they enter the heart of the city, it must be underground. Every principal crossing of country or town is guarded, and there are few wrecks and fewer deaths from crossing accidents; and, still more remarkable, for more than half a century, with the plague raging on every point of her compass, so strict and severe have been her quarantine enforcements that not a single case has crept within her borders.

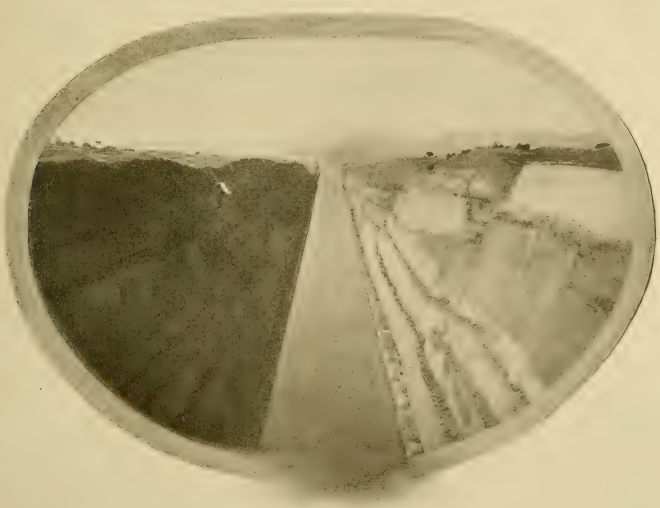
The latest acquisition to the electrical catalogue of Greece is the street railway system of Patras, which is one of the well-equipped lines of the Continent, and boasts of material from half a dozen countries, including the finishing touches from the United States. The construction is simple, and, with enforced delays deducted, it has been rapid. The streets are dug to a depth of two feet, and a layer of crushed stone is put in. A span of track is then fastened by three steel sleepers and placed in position, after which the open spaces are filled in and blocked up with stone and concrete. Within the city limits few poles are to be found, the trolley wire being strung upon cross wires attached to the sides of buildings; but each of the few poles stands for a difficulty with which the company has unsuccessfully contended. Subjected to repeated earthquakes from beneath and storms from above, the one generally following upon the other with sinister regularity, the Greeks look askance at anything which has much to do with electricity. In some cases this prejudice lacked little of superstition, and it became impossible to persuade certain propertyholders to allow a cross wire to be attached to their buildings.

The point of greatest interest about this line, however, is its daring nature as a financial experiment. Not a foot of the road has been constructed from anything but the best of material and only with the greatest care. It runs along the entire sea-front of the city, crosses the new city at right angles to the main line, and penetrates the upper, or old, city to its extreme limits. Beginning again at the western end of the city, it follows the sea for two miles to the popular haunts during the long hot

season, and at the terminus are to be erected coffee-houses and baths. In an American city, probably, of half the size the success of the line would be assured; but in this country the road has to contend with a great deal of prejudice unfavourable to it, with some superstition, and with an immense quantity of pride, the democratic spirit of doing what your pocketbook prompts you to do being conspicuously lacking in this part of Europe. Placed in its proper relations, however, it has a different aspect. For instance, it is controlled by the gas company of the city; hence, when paid for, the running expenses will, it is thought, be lighter than they would be for another company, since the power will be generated by gas engines. The same company also controls the other electric plants of the country. Thus the construction of a system so complete and at such a cost must be set down as the work of far-sighted men who know that the best is the cheapest, that such a project will prove a source of great good to the city, and that in time the city must see it in the same light and so make it a source of revenue to themselves. It is, in truth, an experiment, but one that will scarcely fail, and, with its success, other cities will be ready to follow. A little more time for development, time for the completion of other lines of communication now building, and the most modern conveniences of every description will receive the necessary support from every Greek city of over 10,000 inhabitants on the mainland.

As previously stated, the central power plant at New Phaleron will be the largest of its kind in the Levant, and will compare most favourably with the large plants of Europe. The following list of the seven large plants of Paris will give some idea of the comparative size of the one at Phaleron:—

	H. P.
Usines Municipales	2,450
" de la Cie. Edison	5,600
" " " " du Secteur Clichy	2,800
" " " Société d'éclair et force par d'électricité	5,300
" " " Société des Halles Cen. 1	1,200
" " " " Secteur des Champs Élysées	4,800
" " " Cie. Parisienne d'air Compr.	12,800
Greek Electric Co.'s Plant at New Phaleron	8.620



ALONG THE CORINTH CANAL

THE BUSY PIRÆUS WHARVES

From this table it will be observed that, with the exception of the Compressed Air Plant, of Paris, the Greek plant will exceed by 3000 horse-power the largest of these companies. The ground area occupied will be a little more than two and one-half acres. There will be two power plants proper and a machine and repair shop. A very important addition to the above will be the coal shed, with a ground area of about a quarter of an acre. There will

THE ROYAL PALACE AT ATHENS

be nine engines, seven of which will be of 1200 H. P. each, and two smaller ones of 110 H. P. each. The power house is about 2335 feet from the sea, from which a canal is being built.

As one stands in the shadow of one of the tall chimneys of the plant already completed, with the Acropolis and the temple of Wingless Victory silhouetted against the afternoon sky, and the Mediterranean behind him lapping the sands in the same dignified way it did for Theseus of old, one must prick himself to make sure he is not dreaming. The din of the carpenter's hammer, the rasp of the mason's trowel, the rush and roar of the suburban train on one side and the clatter of the street car on the other, —all these are marks of materialism, the stamp of present-day progress, which, at first thought, seem out of harmony with their classic surroundings. But the most able statesmen of the old school were, after all is said, the most practical, and dreamed dreams, twenty-three centuries ago, for their country which are but being fulfilled to-day. And if Themistocles, to whom the Piræus was as the apple of his eye, could come again upon the scene, taking his bearings from the Acropolis which he would still recognise, he might, perhaps, be heard to say,—"I told you so; I told you so."

As to the uses for the power from this station, there are, first of all, four cities to be lighted by it,—Athens, Piræus, and the two Phalerons, and later on a fifth, Cephisia; and if, as is likely, the price of light can be considerably reduced by this centralisation, it will mean the usurpation of practically every form of light except the candle. There will be power also to furnish for the Athens-Piræus Railway, the only broad-

A PIRÆUS STREET SCENE

gauge railway in Greece. The street railway which passes through the city just in front of the royal palace, and follows the popular drive to the two Phalerons and on to the Piræus, will also be equipped with electricity. It may be of interest, if not strictly of value electrically, to say a word of the contest which has gone merrily on between the street and Piræus lines for some time. When the tram sought the right of way from the suburban line to make a crossing at New Phaleron, the request was flatly refused. Notwithstanding the refusal, the line was extended as near the

ATHENIAN RESIDENCES

limits as possible, was then taken up beyond the railway and completed to Piræus, and traffic opened on both ends. An attempt was then made to bridge the two sections by running out to sea and circling the gardens and grounds of the company, but the railway company crushed the attempt in a decided manner by running an iron pier several hundred feet out into the Mediterranean and erecting coffee-houses at the terminus, at the same time leaving the impression that before the tram should build around them they would run the pier on out to sea, and, if necessary, across to Alexandria. Whether the equipment of these lines with power from a common source will adjust their difficulties remains to be seen. There are also the horse cars of Athens itself, which in due time may be equipped with electricity, provided the notion does not gain too much credence that electric cars in the heart of a city will prove a menace to the public safety, in which event horses will trot, three abreast, at the head of every car in Athens for a decade to come.

But the Greek Electric Company has looked farther ahead than the very near future. The great manufacturing interests of the kingdom are already centered in the Attican plain, and their further development will follow rapidly, to meet the increasing demands and needs of the country. The same difficulty confronts one and all,—the necessity of procuring fuel from abroad at high prices. And if power can be furnished from some other,—any other,—source cheaper, it is from that point that power must be had, and one of the chief objects of the plant at Phaleron is to supply just that power at a price which will make it more profitable to buy energy already generated than to buy the coal and generate it.

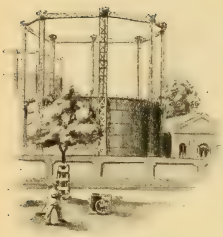
With no coal fields to draw from, no oil and no gas, and with rivers that are, with few exceptions, little short of wet-weather streams, it might seem that there would be no future for electricity in Greece greater than what has been outlined in connection with the power station of the Greek Electric Company. If her power must be brought from abroad, there can be little hope for further development. This may or may not be true. depending more upon other

conditions than upon the mere lack of coal, and is as little likely to cause present uneasiness as the gradual diminution of the sun's heat. There is, however, a power as yet unused, which, it is claimed, may some day be brought into use. Up in the north of Bœotia lies the swampy Lake Copais, and a little south the smaller one, Helike, the former as old as the hills above it, and, from earliest days, an eyesore to the people of that region. Only recently has it been partially filled and turned into arable ground. There is still a good deal of lake left, and acting, as it does, as drainage basin for the Cephissus Major and for the many smaller streams of the northern mountains, it is sure to remain a lake as long as Greece wants it to be one, and longer. It is said that some day the waters of these lakes will be brought down to the plain of Attica and be made to turn the wheels of industry. The scheme has been, thus far, skeptically received; but whether or not such a projected power is ever brought into use, it is at least within the bounds of possibility, and may be taken at its present worth as a source of no little satisfaction to a country in which coal, as one of the great blessings of mankind, might approach unpleasantly close to the line which divides luxury from necessity.

A decade, or two decades, or, for that matter, a century, may not of necessity constitute an age in a country such as this, which goes back of the Christian era fifteen or twenty hundred years for its beginning. Yet unquestionably the past two decades have seen a general revolution in many of the conditions of the country which words are inadequate to properly describe. When it is remembered that less than twenty years ago there was not a single railway in the Peloponnessus, or, in fact, not one in all Greece, unless it may have been the short line between Athens and the Piræus, few good waggon roads, no canal across the isthmus at Corinth, and practically but one modern city in the kingdom, the comparison of the "then" with the "now," when practically every trade centre of Greece has railway connection, and the most remote corners of the kingdom are within a day's journey of the capital, deserves the consideration of thinking people the world over. Whether the electrical developments of the country have kept pace with other lines of improvements is of little moment here. The fact stands that with more than the usual drawbacks to a natural and healthy development of the industry in this little country, the electrical progress has been reasonably, almost surprisingly, rapid, and a true valuation of it is just being formed by the world at large.

MUNICIPAL TRADING IN AMERICA

By Hon. Robert P. Porter, Director of the Eleventh United States Census



MUNICIPAL trading has not been very clearly defined in Great Britain, and the writer believes there exists among those who may be considered authorities on both sides of the question considerable difference of opinion as to the definition. In America this term is not used at all, the accepted one there being "municipal ownership," and of late years that has developed into "municipal ownership of public utilities." The most significant political agitation in America is conducted under guise of this phrase, and those are the words inserted, as a rule, in the democratic municipal, state, and national platforms. For the purposes of this article, and as the terms mean substantially the same, the British "municipal trading" being perhaps more comprehensive, it will be preferable to adopt the latter phrase.

The discussion of municipal trading in Great Britain savours a little of locking the stable door after the horse is stolen. In America we are trying to put the fastenings in order before misfortune overtakes us. Whatever affliction the American invasion may have brought upon the Mother Country, it must plead "not guilty" in this case. Municipal trading is not a Yankee notion. We have had some unhappy experience in lending local and State credit to private enterprise in the days when the people of a new country were anxious to extend railways and canals. We enjoyed our little whirl, and we had to pay the piper. In the forties and fifties an epidemic for helping private enterprise with public funds passed over the land, and the wildest schemes, pushed by unscrupulous promoters, secured the credit of the municipal, county, and state governments. The invariable result followed. Millions and millions of dollars' worth of bonds were issued by public authorities, most of them to become a burden upon the unfortunate taxpayer. In a large number of instances these ventures brought bankruptcy and even repudiation upon cities, counties, and states, and thousands of English capitalists who had loaned their money, as was thought, upon governmental securities, suffered severe losses.

Again, soon after the American Civil War, a craze set in for municipal improvements, and, as a result, local indebtedness and taxes increased so rapidly that in many instances the burden upon taxpayers became almost unbearable, and in important cities repudiation was openly advocated. It fell to the writer's lot over twenty years ago to write the official report of the history of this period, and the lamentable results of throwing private enterprise upon the rates may be studied to advantage in that volume.* These experiences have carried with them useful lessons, and, as we shall presently see, have put a brake on the enthusiastic American municipalists of our own time who demand municipal ownership and operation of "public utilities."

In these demands the American municipalist has been met at almost every turn with the "constitutional debt limit," as we term it. The reader will easily guess that the genesis of the "debt limit" may be found in the fiscal disasters resulting from our early at-

* Report on Valuation, Taxation and Public Indebtedness in the United States, Returned at the Tenth Census (June 1, 1880) by Robert P. Porter, special agent.

tempts in using public funds and public credit in enterprises which should unquestionably be left to individual effort. In seeking a remedy for evils ensuing from the fiscal madness which overtook us before the Civil War, and again in a slightly modified form immediately following that war, the constitutional limitation of debt was hit upon. In some of the more flagrant instances, that of the State of Michigan, for example, the people went even further and declared that the State must not be a "party to, or interested in, any work of internal improvement." So bitter has been the result of the experiments of this State in a theory of government foreign to the sound maxim that "the country is governed best which is governed the least," that the municipalists have never been able to secure a repeal of this provision.

I have not introduced thus prominently the "debt limitation" theory because I believe it fits the British case, but for the purpose of showing its effect in checking the impetuosity of the American municipalist. Go whichever way he may, he is constantly running up against this prohibitory sign. It has blocked his game in all sorts of ways. In the case of Michigan, for instance, after the city of Detroit had purchased a street railway, the Supreme Court compelled the private owners to take it back again. This, too, after clever financiers had unloaded their system on a guileless and unsuspecting council of municipalists at a splendid profit to themselves. In short, so obnoxious have these limitations become that the first number on the municipalist programme in the United States is the repeal of all such constitutional barriers.

So far, these endeavours have not met with success, and the American taxpayer has remained deaf to the stories of great profits in publid utilitias, and stupidly impervious to the tempting accounts of how the taxpayer has become, in some of the British cities, as extinct as the dodo or the pudamonk, while the cities are running themselves on the profits of their gas and electric plants and tramways. Should these alluring arguments prevail, the debt limit be removed, and full swing given to municipal ownership experiments, the American taxpayers will, in my opinion, invite financial catastrophes far more sweeping than any they have heretofore experienced.

The progress of municipal trading in America has not been checked by lack of rhetorical ability or activity on the part of its advocates. Mr. Bryan, who twice contested the presidency on the free silver issue, is one of its vehement supporters, and the idea has become firmly incorporated in the national democratic platform. Mr. Richard Croker, whose studies during his residence in Great Britain have, perhaps, been directed more to the British turf than to the beneficent results of municipal trading, is an advocate of the expansion of municipal industry, and the political association of which he is the head is not unwilling to share in its profits. To these powerful political factors we may add a number of excellent and well-meaning college professors and quasi economists who have confused what Mr. Emilè Garckè, in an interesting address on this subject, so aptly calls the "higher and nobler municipal enterprises" with the more sordid desire of profit making, and are vigorously urging American city councils to follow Great Britain in these hazardous enterprises.

In support of such ideas we have continuously been told of the success of these undertakings, when managed by capable, upright, and experienced town clerks and aldermen of England. The picture has been painted with none too fine a brush, and the pigment, in places, laid on pretty thick. It is not overflattering to ourselves. While the city corporations of Great Britain were reaping enormous profits in gas, in electric light, in efficient tramways, the American taxpayers were being insufficiently supplied with those public utilities at high prices by private companies who were using the streets free of cost and otherwise imposing on the public. So widely have these arguments been disseminated in America that those who have opposed the absorption of private

industry by public officials have been obliged to enter a demurrer in the English case. That is, we have met this avalanche of oratory and rhetoric with the "what-of-it" of the lawyer, and taken the ground that, if all that is claimed is true of the success of municipal trading in Great Britain, the conditions were so different with us that such experiments would be both unwise and dangerous.

I recall the fact that Professor Shaw, the American Columbus of many of these daring British municipal experiments, whose admirable volumes on the subject are well known, when asked by a commission appointed by the State of New York to investigate the question if he would be willing to see his theory of municipal ownership of tramways and gasworks applied to the City of New York, promptly replied,—"I have never dreamed of advocating municipal ownership in New York."

Here, then, has been our difficulty. After dilating to the extent of hundreds, nay, I would not exaggerate if I said thousands, of pamphlets and volumes on the beautiful, but dangerous, course British municipalists have adopted, the more far-seeing and responsible of our own economists,—especially if they happen to be rate-payers,—hesitate when it is demanded that they shall put their theories into practice in their own city.

"Try it," they say, "in some other city or in some other country; but we want no expansion of municipal industry in our own city."

It is the old story of the doctor's unwillingness to take his own physic. Up to within a few years ago this was the situation in the United States. Municipal ownership made an excellent classroom topic, and professors who discussed its advance in Great Britain as an abstract question had little to say about its practical adoption in the United States. Here and there a city owned a gasworks, notably Philadelphia, but in that particular case the management was so abominable and scandalous that when it was turned over, about four years ago, to an enterprising and responsible company, all decent citizens rejoiced. Since then Philadelphia has had better gas, and the city is making a handsome income on the franchise it has granted to the private company.

A few other examples of municipal electric plants and gasworks,—those of Toledo and Columbus,—recently were sold to private companies after a sad history of loss to the rate-payer and scandal in respect of the municipal government. In a report made by the United States Department of Labour two years ago, I find that of about one hundred and fifty of the principal American cities, more than two-thirds, including large cities, own and operate their own waterworks. A glance at the column relating to gasworks and electric plants reveals the fact that only two or three cities own their gasworks and about a dozen their electric plant, while no city is reported as owning its own tramway. This may be substantially regarded as the condition of affairs at the present time. America seems to have been more successful than Great Britain in drawing the boundary line, as it were, between legitimate and illegitimate municipal undertakings.

Rightly or wrongly, the Americans have drawn the line at waterworks, on the ground that the water supply of a city is closely allied to its sanitary conditions, and that there is no injustice in levying tribute, relative to the ability to pay, for a good and sufficient water supply. There exists in Great Britain, I know, a difference of opinion on this point, but I believe the boundary line can be drawn on the ground that those who cannot afford to pay water tax should be compelled to use water, anyway, and that their not using this necessity freely not infrequently endangers the health of their neighbours. Especially is this true in the case of tenement-houses where the population is more or less congested.

In the cases where the water supply in the United States is in the hands of private companies the cities have either been unenterprising or perhaps the "debt limit" may have prevented the purchase of the waterworks. The tendency is, I think, for cities to take over

the waterworks, and there seems to be no objection from any quarter. The statistics found in the current issue of the English Municipal Year Book show dealings with this problem to be more erratic than ever.

Great Britain has dashed ahead along some lines that in America we should regard as extremely hazardous, and in other directions, the control of waterworks, for example, it has taken the opposite course. Thus, one is surprised to find the London County Council running omnibus lines, erecting small, but expensive, electric plants to supply limited areas of street lamps, building tramways, planning extensive subways from Westminster to the Bank, while the water supply of the greatest modern city is in the hands of private companies. I am aware of the efforts made to purchase London waterworks and of the obstacles in the path, but think that the desired result could have better been obtained had the County Council concentrated its energies, instead of going into too many irridescent schemes. The trouble with that body, as it appears to an outsider, is, that it scatters too much. The tendency to scatter or spread out into too many things is dangerous to a business man,—it is ruinous to a public body. There is no constitutional limit to the debt-creating power of the London County Council, but the price of its securities suggests that a large increase of those bonds might not be practical.

Looking over the entire field, I find about half the capital invested in British tramways owned by municipal authorities; about one-third of the capital in gasworks; by far the largest portion in electric light plants; but only half the municipal boroughs of Great Britain seem to own their waterworks. These general facts indicate the difficulty which will be found in defining just where municipal enterprise in such matters should rightly end and private enterprise begin.

Within the last few years a change seems to have come over this municipal dream in Great Britain. While we, as I have said, have been obliged to argue our case in the United States on a demurrer so far as Great Britain's experiences were concerned, there has arisen a perverse British generation which has set about the demolition of the idols before which we have been told to bow down and worship. The attack on the temple of municipal trading has been sharp and decisive, and the edifice as it was once represented to us in the United States has been badly shaken. This has been accomplished by the aid of several different organisations, prominently among which I notice the British chambers of commerce. Then there was the Society of Arts debate, the Royal Statistical Society's investigation of the financial side of the question, the Parliamentary committee, numerous able pamphlets, and, more recently, that powerful ally, the London *Times*.

Britain having thus defaced the edifice of her own efforts, we foreigners must not be asked to gaze upon what is left and pronounce it complete and satisfactory. We are more likely to enter the sacred precincts through the apertures made in it and endeavour to solve the mystery of its departed power. We may even be encouraged to compare the cost of some of these boasted achievements with similar undertakings of our own. We might be tempted to ascertain if under a different method we have been able, by utilising individual effort and private capital, to give the public as cheap and as efficient service.

The readers of CASSIER'S MAGAZINE are too familiar with the shortcomings of municipal trading to need a recapitulation in this article. British industry found that it did not fit in with the extension of modern enterprise. It was desired to distribute electrical power and sell it cheaply for all sorts of purposes, and such enterprise was blocked by a combination of town clerks. There was a demand for cheap producer gas for use in gas-engines, but municipalities whose business interests prompted them to oppose cheap power put untold obstacles in the way.

So it is with light,—electric and gas,—and with the extension of tramways and light railways. Then it was discovered that those towns and cities, with

their retinue of officials, had been merely nibbling at the electrical industry. Private enterprise had been dampened and dwarfed by hold-ups in the shape of provisional orders. Meantime, Great Britain was behind even Italy in an industry in which she should, by right of priority and practical application, have led Europe, and been side by side with the United States. When these facts were fully established, British ire was thoroughly aroused. Whatever may be the final outcome, and whether private enterprise ever comes to any understanding with these authorities as to boundary lines, or not, these attacks have weakened their power. If municipalities still, as is probable, cling tenaciously to that which they have, they will have to fight harder for that which they may in future wish to appropriate. The municipal traders may preach "on finality to municipal trading," but Parliament, the limitation of debt-creating power, the patience of the rate-payer, and the necessity of encouraging British industry, will prevent its being carried out.

As I have said, until the time of the severe attacks on municipal trading referred to above, we had been given to understand in America that in Great Britain wonderful success had attended the efforts of municipalities to monopolise individual endeavour or enterprise. The appeal, however, was chiefly made on the exceedingly fallacious ground that the "profits" thus extracted from the pockets of the capable and enterprising, the energetic and far-sighted, the ingenious and the inventive, were enabling the rest of the community to live free of taxation. Herein lay its chief attraction. Mr. Donald, editor of the *Municipal Journal*, has disposed of this point himself, and thus denudes his whole theory of "no finality to municipal enterprise" of its principal charm to American municipalities by the following declaration:—"It would be preferable in all cases that municipalities ceased to make profits from their undertakings,—whether gas, water, electricity or tramways."

Here we have an advocate of municipal trading in Great Britain abandoning the very essence of the argument of his co-labourers across the Atlantic. The bait of lower taxation is the luscious morsel which the Bryanite orator and American college professor have been dangling before American taxpayers. Without it, the subject will not prove permanently attractive, and hardly command respectful attention.

The Parliamentary Committee on Municipal Trading has given the British public full information on the merits and demerits of municipal trading. Much of the work done by British cities deserves nothing but the highest commendation from the American side of the Atlantic. Here and there we are endeavouring to follow in British footsteps in all matters that contribute to a higher civic life. We have only recently carried on a united and non-partisan fight to rescue New York from the evil influence of the Tammany Association. Municipal government, in the United States, is not so bad as it is sometimes painted, and in many cities of medium size honest and capable government is enjoyed. We are willing to follow British municipalities in the higher and nobler work they are doing, providing it does not take us along the dangerous river of municipal trading into the unknown sea of socialism. The expansion of the functions of municipal government for the protection of public safety and public health is legitimate, and should be encouraged. The question to be solved is,—"Must the economic and idealistic functions of municipal government expand in like manner?" We have gone around the circle, and here we are back at the old issue which marks the parting of the ways.

There will be more difficulty in finding the safe road in Great Britain than in the United States,—that is, if municipal ambition can only be held down to non-profit producing undertakings. John Boyd Thatcher, mayor of Albany, once said in speaking on this subject:—"If the city may do those things for the individual which he cannot do for himself, may it do for him those things which he finds it inconvenient to do for

himself? If it may care for his safety and health, may it also care for his morals and his comforts? If it may build him an academy to educate a sound mind, may it build him a gymnasium to develop a sound body? If it build him a gymnasium to train his muscles, may it erect an arena to test his prowess? If it publish police rules and regulations for his conduct, may it establish an ethical college to teach him the foundation of obligation? If it may teach him ethics, may it teach him religion? And may all these things be done at public expense? Here our vessel breaks from its moorings and drifts toward the beautiful, but dangerous, coast of Paternal Government."

These words are quoted because they summarise the arguments which those who oppose it meet with every day. Those who believe in and want paternal government and socialism frankly say they favour the whole socialistic programme, that a city should conduct all functions, from divine worship down to the manufacture of tooth-brushes. Those who do not believe in socialism, and yet persist in enlarging the sphere of municipal trading, should realise that by the destruction of individual effort they are rapidly undermining the very foundation of their country's strength and greatness.

If the State or city takes away, one after another, the opportunities for profitable employment of private capital and brains,—the latest proposal being fire insurance,—the logical result is that other occupations become overcrowded, the struggle for existence grows harder, and an increasing number of persons must come upon the State or city for support.

The State's function is to give every man an opportunity to do business under a stable government. The question will be asked, is it safe to trust municipalities to do all these things at public expense? In spite of the cry, "No finality to municipality enterprise," there will be a finality when, as Mr. Thatcher suggests, the vessel of municipal trading drifts towards the alluring, but dangerous, coast of paternal government. Germany has lately set her face against municipal ownership and operation of public utilities, for the simple reason that she had carried officialism as far as it was prudent to go. The government employees tended always to increase; and there, as in Great Britain and America, it was found that employment by the government signified much which did not at once appear. The line had to be drawn somewhere. Even in Germany it was not considered expedient to add to the number already existing the numerous officials and employees of all the street railway systems in the empire.

Of the fact that State or municipal ownership deadens enterprise there can be no sort of doubt. That the timid policy of the British Parliament in tying great modern enterprises to the apron-strings of local political boards by such legislation as the Tramway Act, the various lighting Acts, and now the Telephone Act of 1899, has had much to do with the backward condition of the electrical and other great industries, is proved by the testimony before the Select Parliamentary Committee. In a like manner the overzealous Corporation in thwarting company enterprise, because of its own investments in these undertakings, has soaked the activity out of private capital and kept it back from channels which it would otherwise have sought, to the benefit of the kingdom at large. In short, it has chilled enterprise.

In the United States, capital in these industries has had a freer headway,—not a go-as-you-please, as some seem to imagine,—than in Great Britain; and, in my opinion, the results have been more satisfactory. Private enterprise may need curbing a bit, and this work our various State legislatures seem fully competent to perform. Better let such undertakings become profitable, and reward individual endeavour and enterprise, than by unjust impediments and State and local "jay-hawking," leave them in a moribund condition.

Perhaps, in conclusion, I may be pardoned for saying a word on what we have accomplished in the United States

in certain branches of industry which British municipalities seem to watch over so zealously. Take, for example, our twenty thousand miles of street railways, not a mile of which is under the fostering care of a town clerk,—though some of it may be in the hands of a receiver, —" better that," some will say, " than on the rates." The private capital involved in this industry,—almost brought into existence since the introduction of electricity as a motive power,—is variously estimated from three hundred to four hundred million pounds sterling. American gasworks and electric light plants have gone on increasing side by side. When electric light was first introduced, gas stocks went down, but private capital soon rallied and individual courage invented new methods to make gas cheaper, and new avenues for its use,—power producing, cooking, etc.,—so that the consumption of gas has doubled and trebled, while electric lights are being strung up all over the country.

To-day, I am told by one of our greatest experts, the best, steadiest, and cheapest electric light can be made with the aid of gas and the utilisation of the gas-engine. Yet some British municipalities are snapping at private capital and holding up provisional orders for electric plants because they own and operate gas plants, and are doing all sorts of other queer and antiquated things, based, I believe, on the theory that gas and electricity are rivals.

There is too much of the spirit of " you–must–have–what–we–have–got " about this municipal trading idea to make it popular in the United States. If private capital wants to take the risk to give a community cheaper transportation, cheaper and better gas, to encourage its use for cooking or for manufacturing purposes by distribution over large areas, by all means let them do it. If individual effort and private capital want to start electric light plants or distributing power houses, the way will be found in an American city. Energy of this sort in America is not found hopelessly knocking at the city gates, as at some of the modern " walled municipalities " of Great Britain.

" That is all very well " one hears our municipal friends say, " but we must keep out these tramways, and gas, and electric, and telephone, and telegraph companies, for they spoil our streets and run their rails, and mains, and poles, and elevated structures, and tunnels, and subways in every direction, and the public get nothing in return."

While I do not propose in this article to be enticed into a defence of all the private company iniquity of the United States, and while there has been, and is now, much that is reprehensible in their actions, we are still obliged to admit that the general result has been satisfactory. Public officials are giving more attention to these matters, and the rights of the public are much more carefully guarded than heretofore.

A municipal trading city may make a profit on its transportation, its gas supply, and its electric lighting. It is for those who represent private enterprise in Great Britain to demand to know how the profit compares with the amount of money which American private companies working such undertakings annually pay into the city and State treasury for the right to use the streets for various purposes. Mr. Garckè has given us, I think, nine sound principles which should be strictly adhered to in making fiscal comparisons between corporations and company undertakings. Prominent among these should be an estimate of the taxes which a municipalised city loses by owning and operating its own profit-making enterprises.

One of my municipalistic friends said to me the other day, that the city was entitled to every penny of the profit from such enterprises. Suppose, for argument's sake, we admit this assumption. Having done so, can we not conceive of a condition wherein private enterprise, with its greater experience, its scientific experts, and with its bolder operation, might bring better results, in a given field, and while yielding a profit for its own capital and a reward for its own enterprise and experience, — which should not be given grudgingly,—still pay a greater sum into the city treasury and at the same time serve the public

more cheaply and more efficiently? Take, for example, the Brooklyn Rapid Transit Company, paying over a million dollars annually as taxes. It has worked up an extensive business in transportation, has consolidated smaller tramways, pays the city nearly two hundred thousand dollars annually for the privilege of carrying passengers from New York free across the Brooklyn Bridge, and will even carry passengers twenty-two miles at a good speed for the modest fare of five cents, or two pence half-penny. Then, again, the Metropolitan Street Railway, of New York, carrying nearly two hundred million passengers on transfers free of cost,—ten million dollars thrown away, some people contend. Surely here America can match the British municipalist half-penny fare of which one hears so much.

This bold stroke on the part of the Metropolitan Street Railway, of New York, of free transfers, brings business just as would be the case if some great central railway company secured the underground and tubular railways of London, electrified the roads, unified the fares, and sent the passengers night and morning in whichever direction they wished without thought of greater and less fares for greater and less distance, or of class, for a run of ten or fifteen or even twenty miles around London.

This same Metropolitan Street Railway has just "scrap-heaped" a good cable plant worth over five million dollars because it stood in the way of electric progress. The same company last year paid nearly a million dollars in taxes, without counting the value of paving and street cleaning, and removal of snow, which, under the agreement, they have to do on streets over which their tracks run, and which is charged in with the operating expenses of the company.

The Union Traction Company, of Philadelphia, have, for this article, made an estimate of their taxes, and, including the cost of the maintenance of paving, removal of snow and ice, and the interest on the original $14,000,000,—the cost of improved pavements laid by the company at the time the franchise was granted,—this aggregates over $2,000,000 annually. These would seem goodly sums, and certainly dispose of the assertions that the American street railway companies use the streets free. The official report from Massachusetts shows, on gross receipts of about $23,000,000 for all street railways of the State, taxes of $13,500,000,—about 6 per cent. of the gross earnings.

These companies also pay out enormous sums for injuries and damages. American courts are severe on the railways and the juries liberal to the injured passenger. The Brooklyn Rapid Transit paid last year $800,000; the Metropolitan Railway, of New York, $335,000; and the street railways of Massachusetts, $600,000. The Manhattan Elevated Railway, of New York, besides its very heavy annual taxes, has paid, since its existence, $12,500,000 in claims for damages, and has an equal number of claims still pending.

Here and there large fortunes have been made out of these ventures, but the street railway companies of the United States, when enormous items of special expenditure as above indicated are deducted, are not making as much money as the municipal trader seems to think. The same holds true of companies supplying gas, electricity, telephone communication, and telegraph service. The British Government is losing heavily, I understand, on its telegraph business. We have two competing companies which give us a good and cheap telegraph service, and both seem to make reasonable dividends, in spite of the inroads of the telephone.

The unhappy story of the British telephone industry, divided now under three heads,—governmental, municipal, and private,—is too familiar to readers of Cassier's Magazine to require more than a passing reference. A strong company, if given a fair chance, would have, in my opinion, served both public and State more satisfactorily. The telephone is of real value in the United States, because it works well, the connections are quickly made, and it is easily reached. In our large cities pub-

lic telephones may be found on almost every block. Our telephone stations in some cities are places of luxury, where you may read the latest newspapers and smoke while waiting, and when your "calls" are answered, do business all over the United States. Sharp-witted and quick American girls serve you with civility and promptitude. If you do not get the person you want, you do not pay. The trouble some of these operators take to connect the proper exchanges and get the right people on the telephone would astonish the coolly indifferent operators in British postal or trunk-line exchanges. It is private business, and in many instances competing business. It pays to push it. And it is vigorously pushed.

These few facts are not submitted in a boasting spirit. We have in America by no means solved these problems, and have much to learn in dealing with them. Again, conditions differ so widely that what may be suitable for us might not be practical in Great Britain. We have begun much of this work with a clean white sheet before us, and have worked out our plans without the numerous obstacles which an older civilisation like that of Great Britain places in the way. If I have been able to show that we are not quite so foolish in dealing with these franchises and conducting these extensive business operations as some municipalists seem to imagine, this article will have answered its purpose; and if our experience will help those in Great Britain interested in private endeavour to a greater development in such industries, I shall be happy, and shall have accomplished all I could possibly hope for.

ELECTRICAL ENERGY DIRECT FROM COAL

By J. Wright

THE successful solution of the problem of how to obtain electrical energy direct from coal would go a long way towards revolutionising existing methods in the engineering and scientific world generally, in that a more or less immediate application of enormous resources of power, without the intervention of the present cumbersome boiler, engine, and dynamo, would thus be rendered possible, and solve many of the existing problems which are on the eve of solution, such, for instance, as aerial navigation.

With existing methods for the production of electrical energy on a commercial scale, by means of high-grade boilers and high-efficiency steam engines and dynamos, only about 6 per cent. of the latent energy stored in coal is available at the terminals of the generator. Any system, therefore, which would tend to render this enormous store of energy immediately available, even to the extent of 50 to 60 per cent., would be exceedingly welcome to the engineer and the scientist, and it is with the object of summarising what has already been done in this connection, and in what direction such minor successes point for a final solution, that the following paragraphs have been penned.

One of the earliest discoveries in connection with this problem was that made by an engine-driver named Seghill in 1840, which culminated in the construction of Sir William G. Armstrong's hydro-electric machine. Seghill elicited the fact that steam, issuing, under pressure, from the safety-valve of a boiler, becomes electrified. Armstrong and Pattinson investigated the phenomenon, and found that it was due to the friction of the minute particles of water, or condensed steam, against the walls of the passage providing the exit, and on this fact was based the construction of the historical machine which consisted of a boiler and furnace mounted on four strong glass insulating pillars and provided with the usual gauges and steam dome, from which latter the outlet pipes were led into a species of iron chamber for the purpose of partially condensing the steam prior to its liberation, it being essential to the success of the device that the escaping steam should carry as much moisture as possible. With a similar object in view, and also to increase the frictional resistance offered to its passage, Armstrong constructed a series of wooden nozzles, in passing through which the steam was caused to impinge upon a disc and pass around the edge of the latter. In front of the nozzles was placed a series of metal points forming a collecting comb, against which the particles of condensed vapour were projected. This comb was carried by a second insulating pillar, which served as the positive terminal of the apparatus, whilst the boiler constituted the negative terminal.

With this machine Sir William Armstrong succeeded in producing large quantities of static electricity, which, in discharging from pole to pole, developed sparks from 5 to 6 feet long. The hydro-electric machine proved, however, to be impracticable and inefficient for the production of electrical energy from coal on a commercial scale, and, as a natural consequence, the discovery has never overstepped the boundary imposed by the term "interesting scientific experiment."

A still earlier method of generating an electric current from the heat of combustion of coal is by what are known as thermopiles. As far back as 1822 Seebeck discovered that a current is produced in a closed electric circuit by heating the point of contact of two dissimilar metals forming part of that circuit. The electromotive force of the current produced in each couple is very small, and depends upon the two metals selected to form the thermo-electric couple. As the result of his experiments, Seebeck compiled the following table of metals, arranged in their thermo-electric order, each metal being electro-positive to those which follow it in the list:—

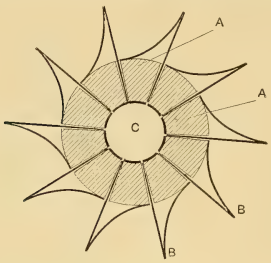


FIG. 1.—CLAMOND'S THERMOPILE

(+) Bismuth	Copper	Silver
Nickel	Lead	Zinc
Cobalt	Tin	Iron
Platinum	Gold	Arsenic
		Antimony (—)

If any two metals be selected from this list, and a good electro-mechanical junction be effected between them, the heating of this junction will produce a flow of current from the electro-positive metal to the electro-negative through the heated junction. Alloys also are available for the production of thermo-electric currents, and Seebeck compiled a second list of metals and their combinations, in thermo-electric order, as follows:—

(+) Bismuth	3 Bismuth, 1 Lead
Lead	1 Antimony, 1 Copper
Tin	1 Antimony, 3 Copper
1 Bismuth, 3 Tin	1 Antimony, 3 Lead
1 Bismuth, 3 Lead	1 Antimony, 3 Tin
Platinum	Steel (cast)
1 Bismuth, 1 Lead	Steel (rod)
Gold	3 Bismuth, 1 Tin
Silver	1 Bismuth, 3 Antimony
1 Bismuth, 1 Tin	Antimony
Zinc	1 Antimony, 1 Tin
	3 Antimony, 1 Zinc (—)

Seebeck's discovery led to a number of praiseworthy attempts to apply the thermo-electric principle to the practical generation of electrical energy on a commercial scale. The resulting devices are known as thermopiles, and consist, in the main, of a number of thermo-electric couples, connected together electrically in order to combine their resulting electromotive forces, and constructed physically in such a manner as to facilitate the simultaneous heating of all the junctions from a central source.

One of the earliest thermopiles was that of Markus, constructed in 1864-65, which gained a prize from the Vienna Society for the Promotion of Science. The positive metal was an alloy, consisting of twelve parts of antimony, five parts of zinc, and one part of bismuth, and each electrode consisted of three strips fastened together by screws. The negative electrode, on the other hand, was an alloy consisting of ten parts of copper and six parts of zinc and nickel, and was made in the shape of a rectangular bar. A number of these elements were connected together after the manner of lattice-work, and placed in two rows, sloping together at their apices, and forming a structure not unlike the roof of a house. The ridge of the

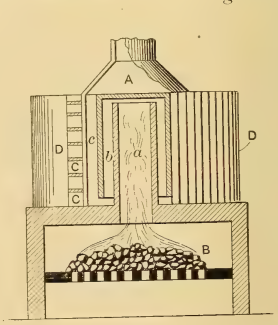


FIG. 2.—AN IMPROVED CLAMOND PILE

"roof" was constituted by an iron bar, to which the junctions were severally attached by means of screws passing through the bar; mica plates and bushings were interposed between the couples

and the bar in order to insulate them, and heat was applied to the junctions through the medium of the iron bar itself, which was supplied with heat from a convenient source. The junctions between neighbouring couples were effected at the lower edges of the slopes and immersed in cold water, in order to make the difference in temperature between the two sets of junctions more marked. The electromotive force of each of these couples was equivalent to one-twentieth of that of a Daniell cell.

Clamond's original thermopile was constructed in cylindrical form, the principle of construction being represented in Fig. 1, which shows a transverse section through one set of couples. *A A* are sector-shaped blocks of an alloy of zinc and antimony, arranged in a circle, and to their inner and outer surfaces are attached the sheet-iron plates, *B B*, these latter being extended, as shown, beyond the normal periphery of the circle, in order to provide an increased surface for the radiation of heat, thereby keeping the outer junctions cool. Several sets of electrodes thus constituted were placed one above the other, and separated by insulating pieces. The central tube or chimney, *C*, thus formed was lined with asbestos cement, and an earthenware tube, pierced with a number of holes to serve as a multiple-jet gas burner, was introduced, and supplied with gas from a convenient source.

In 1879 an improved form of Clamond pile was described by Th. Du Moncel, which was capable of being energised by the heat from a specially constructed coke furnace. It is represented in sectional elevation in Fig. 2, and consists of a zigzag flue *a b c*, made up of three concentric cylinders, communicating with one another at the top and bottom, as shown. The last of these cylinders, *c*, leads into a chimney, *A*, whilst the first receives the hot gases resulting from the combustion of coke in the furnace *B;* the heated gases of combustion are thus compelled to pass three times over the inner surfaces of the cylinders before finding an exit. *C C* are sheet-iron elements arranged immediately outside the cylinder *c*, whilst *D D* are vertical copper plates arranged radially, in order to secure a large surface for cooling the outer junctions by radiation. Cazin records that two such thermopiles, 98 inches high and 39 inches in diameter, each comprising thirty sets of one hundred couples each, were capable of generating current at an electromotive force of 109 volts, and offered an internal resistance of 15.5 ohms. The consumption of coke to achieve this result is stated to have been twenty-two pounds per hour.

Nöe and Hauck also constructed thermopiles on a circular plan; in fact, Clamond's original pile seems to have

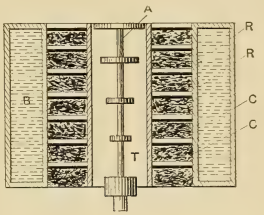


FIG. 3.—COX'S THERMOPILE

set the fashion in this respect, and a very convenient form for heating is thereby procured.

Cox's thermopile is one of the most modern productions in this field, and was, until a short time ago, obtainable in Great Britain, but it is understood that its manufacture has been discontinued. A diagrammatic view of its internal construction is represented in Fig. 3, where *R R* are the thermo-couples, arranged in annular form, and separated from one another by insulating pieces, *C C*. The central tube, *T*, is lined with fireclay and heated by a Bunsen burner, the flame from which is spread outwards against the walls of the tube by a special device, *A*. *B* is a water-jacket, provided with inlet and outlet pipes, and so arranged, immediately outside the outer junctions, as to keep them cool by the circulation of cold water whilst the pile is active. The stock patterns of this pile had electromotive forces of 3, 3.5, 4.5, 5, and 8.5

volts, and were capable of generating 4, 4.5, 3.5, 3.2, and 2.5 ampères, respectively.

There are several other types of thermopile, all of which, however, are similar in principle to the three already described, and which will serve as examples of their kind.

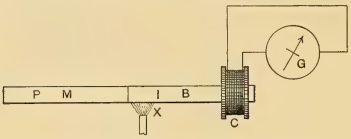


FIG. 4.—THE PRINCIPLE OF TESLA'S PYRO-MAGNETIC GENERATOR

To sum up, the thermopile is an extremely inefficient device for the production of electrical energy from heat, and possesses also several inherent defects, which render it unsuitable for any but a few special requirements. Chief among the drawbacks of this type of generator are, firstly, its necessarily high internal resistance, owing to the fact that the hot and cool junctions must be separated by an appreciable expanse of metal; secondly, the difficulty of preserving, for any length of time, good electrical conductivity at the junction, owing to oxidation and other causes; and thirdly, the extremely rapid depreciation of the pile, owing to the sudden extremes of temperature to which its parts are subjected, and which give rise to consequent expansion and contraction of the metal, tending to loosen all joints, and, in time, prove the destruction of the whole pile.

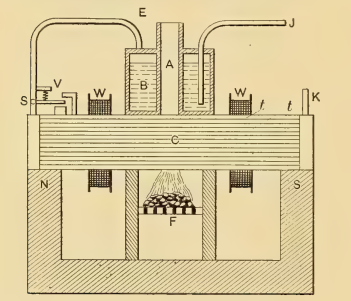


FIG. 5.—TESLA'S GENERATOR

Having thus briefly considered the subject of thermopiles, let us next proceed to discuss what are known as pyro-magnetic generators of electrical energy. At the beginning of the seventeenth century Dr. William Gilbert elicited the fact that natural magnet (loadstone) or a magnetised iron bar, if subjected to a red heat, loses its magnetic properties. On this discovery one or two devices for the generation of electrical energy have been based, and I will first proceed to deal with the work of Nikola Tesla in this direction. Tesla based the design of his pyro-magnetic generator on the above fundamental principle, and also on a second law, which is to the effect that if any conducting body (electrically considered) be subjected to a varying magnetic influence, electrical energy will be developed in that body. These two first principles may be ably demonstrated by a simple experiment, suggested, I believe, by Tesla himself. Referring to Fig. 4, if a permanent bar magnet, *P M*, be placed end on to, and in contact with, an iron bar, *I B*, in such manner as to magnetise the latter by contact, and a coil, *C*, be wound round the outer extremity of *I B*, and connected in circuit with a galvanometer, *G*, as shown, then on heating *I B* at the point *X*, by means of a suitable flame, until it becomes a bright orange-red, indicating a temperature of about 600 degrees C., the magnetism in *I B*

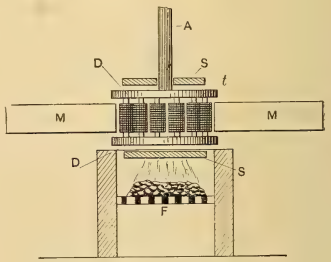


FIG. 6.—EDISON'S GENERATOR

will disappear, and, in its passage, give rise to a current of electricity in the coil, *C*, which will be duly recorded by a deflection of the galvanometer needle. On removing the source of heat and allowing *I B* to cool, its magnetic properties will again return, with the production of a second current in *C*, which, however, will be flowing in an opposite direction to the first, as indicated by the galvanometer needle, which will swing over in the opposite direction.

Tesla's suggestion for the application of this principle in practice is shown in Fig. 5, where *N S* represents a powerful magnet, the poles of which are bridged by a rectangular iron casing *C*, containing a number of iron tubes *t t*, the whole forming an armature or "keeper" to the magnet *N S*. Around the casing are wound coils of insulated wire *W W*, in which the resultant electrical energy is to be generated. The armature passes through the centre of a specially constructed furnace *F*, provided with a chimney *A*, and surmounted by a boiler *B*. A water inlet pipe, *J*, and steam outlet, *E*, are fitted to the boiler the steam outlet being led round to the common entrance of all the tubes, *t*, as shown. An exhaust pipe, *K*, is provided at the opposite extremity of the armature. *V* is a steam valve, actuated by a spring-controlled lever, *S*, which, when the armature is magnetically active, is attracted downwards, and closes the valve. On the centre of the armature becoming heated by the furnace, it loses its magnetism, with a consequent production of electrical energy in the coils *W*, and the release of the lever *S*, which is drawn up by its spring, opening the steam valve, and allowing steam to enter the armature. The steam exercises a cooling effect on the latter, with the result that its magnetism returns, a current is again produced in *W W*, and the steam is automatically cut off, as before, and so the cycle of operations goes on. The main drawback to this and other types of pyro-magnetic generator is their necessarily sluggish action, a perceptible interval being necessary to allow the active portion of the magnetic circuit to assume its extremes of temperature. In 1887 Edison turned his attention to this type of generator, and succeeded in producing a machine of 1500 pounds weight which was capable of developing electrical energy to the extent of 3 H. P. The principle of Edison's generator is represented in Fig. 6, where *M M* are a number of horizontal magnets, arranged radially with their inner poles towards a centre vertical shaft, *A*. On the latter, and so mounted as to revolve with it, is fixed an armature, consisting of a number of vertical iron tubes, *t*, one two-hundredths of an inch in thickness, and mounted, top and bottom, in thick iron discs *D D*. Each of the armature tubes is wound with an insulated wire coil, the ends of which are led to a commutating device (not shown) by which the resulting currents may be rendered unidirectional. *S S* are refractory earthenware or fire-clay screens, arranged, one above, and the other below, a segmental portion of the tubes *t*, so as to screen some of them from the heating effects of the coal furnace *F*. On rotating the armature, those tubes which are open to the furnace lose the magnetism which they receive by induction from the magnets *M*, and a current is generated in the coils surrounding them; on passing over to a position in which they are screened by the segments *S S*, they become cool, with the result that their magnetism returns, and a second current is generated in the coils.

Edison's device possesses several defects; firstly, it is heavy, compared with the output of energy; secondly, its iron tube armature, owing to the fragile construction necessitated, speedily disintegrates; and, thirdly, it can be run only at a slow speed, about 120 revolutions per minute. A generator on a similar principle to the foregoing has also been designed by M. Menges, of Holland, the necessary heat energy being supplied by a number of gas jets.

All the devices so far described for the production of electrical energy from coal have depended on a primary conversion of that latent energy into heat by direct combustion in a furnace. This,

in itself, implies considerable waste, in that many of the elementary bodies contained in the coal are either consumed or pass off in the form of vapour or gas without yielding a proportionate return as heat energy. We must look, therefore, for a more direct conversion than that represented by direct combustion pure and simple.

Volta's valuable discovery at the close of the eighteenth century which resulted in the evolution of the ubiquitous primary battery opened up a wide field for scientific research in connection with the production of electrical energy by chemical action. The element mainly concerned in the production of electrical energy by voltaic action is zinc, and this metal is, unfortunately for the success of the problem, far less plentiful than coal, so that, to contrast the two substances from the point of view of commercial economy in the production of current by known methods, shows a decided balance in favour of coal and the steam engine. With the object of overcoming this drawback many attempts have been made to substitute carbon, the predominant partner in the composition of coal, as the element to undergo combustion in a voltaic cell.

Here we are met by difficulties of a grave nature. Coal *per se* is a poor

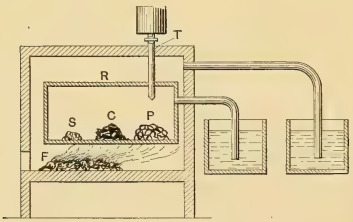


FIG. 7.—REED'S PROCESS

conductor of electricity, but is readily converted into a good one in the shape of coke, which is almost all carbon, and, moreover, gives up valuable by-products in the process of conversion. Then, again, it is essential to the success of a voltaic cell that the positive, or consumed electrode, should be strongly electro-positive, and this, in point of fact, carbon is not, being rather the reverse, and electro-negative to all but a few elements, thus rendering the available range for the selection of a suitable negative very limited in character. To crown all, carbon is insoluble in all ordinary solutions, thus introducing another difficulty,—the selection of an electrolyte.

Despite these various drawbacks, many attempts have been made to employ carbon as a positive electrode in a battery for the generation of electrical energy by voltaic action, and the writer will proceed to deal with one or two of the most noteworthy methods.

C. J. Reed's process, which was first published in 1896, is represented in Fig. 7, where *R* is a retort, mounted upon a suitable furnace, *F*, and containing the separate ingredients *S* and *C*, consisting of sulphur and carbon, respectively. *P* is a small mass of pebbles, over which water is allowed to trickle from a supply tube, *T*. The furnace *F* is fed with sulphur, which, by its combustion, is converted into sulphur dioxide gas; this passes out at the exit flue, and is collected by solution in water, forming sulphurous acid. The heat thus generated causes the sulphur *S* to vapourise, and the vapour, in passing over the mass of heated carbon *C* is converted into bisulphide of carbon. Simultaneously, the heat of the furnace *F* produces steam at the point *P*, and this steam, mingling with the carbon bisulphide vapour, forms sulphuretted hydrogen and carbon dioxide gases. These two mixed gases also pass over into water, which readily dissolves the sulphuretted hydrogen, but the carbon dioxide sparingly,—in such small quantity as to render it negligible. Sulphurous acid and sulphuretted hydrogen solution, thus formed, are placed in a two-compartment vessel, separated by a porous partition which permits diffusion. As electrodes, a carbon plate is placed in each liquid, and the resulting voltaic action produces water and sulphur, giving rise to an electromotive force of about 0.36 volt. Unfortunately, the diffusion, and consequent combination of the two liquids, goes on all the while,

whether the external circuit be open or closed; there is thus considerable waste, and the electromotive force being very low, this arrangement has not proved itself commercially practicable.

Another device, the introduction of which at about the same time created quite a furore in scientific circles, is that of Jacques, and is known as the Jacques cell. It is represented in diagrammatic section by Fig. 8, and consists of a furnace, *F*, over which is mounted an iron retort, *R*, which constitutes the negative electrode of the battery. Placed axially in this retort, but insulated from it by the lid *L*, is the carbon, or positive electrode, *C*, immersed in a mass of fused caustic soda, *S*, contained in the retort *R*, and maintained in a state of fusion by *F*. *P* is an inlet pipe for atmospheric air, under pressure, from a pump, the stream of air being distributed under the lower extremity of the carbon electrode by a perforated head, *H*, similar to the rose of a watering-pot.

The action claimed for this type of generator is as follows:—The oxygen of the air, in the presence of the fused caustic soda, unites with the carbon to form carbon dioxide, which passes off from the retort in the shape of gas, whilst the electrolyte remains unchanged, and can, in consequence, be used indefinitely. An electromotive force of one volt is produced at the terminals of the cell. Theoretically, this action looks very pretty, but the actual reaction which goes on is still, to a certain extent, shrouded in mystery. Suffice it to say that, in practice, carbonate of soda is formed in no inconsiderable quantity, and this, together with other impurities emanating from the carbon, tends to destroy the utility of the caustic soda in course of time. Moreover, an extraneous source of heat, the furnace *F*, is required to work the cell, and also an auxiliary pump for the air supply, both of which items considerably detract from the economical working of the apparatus.

Blumenberg's cell is very similar to the foregoing in its construction and the principle on which it depends for the generation of an electric current. The carbon and containing retort of iron or copper are arranged as in the previous apparatus, whilst the caustic soda is mixed with lime and cryolite. The air-pump of Jacques' cell is rendered unnecessary by the addition of an annular boiler which surrounds the retort and is heated by the same furnace. The steam generated is led into the electrolyte, and, by its decomposition into its constituent elements, hydrogen and oxygen, supplies the place of the air in the former device.

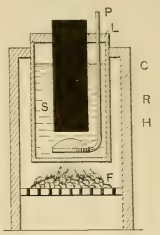


FIG. 8.—THE JACQUES CELL

Whilst on the subject of voltaic action, we must not forget the valuable services rendered by Sir William Grove in his discovery, in 1839, of the "gas battery," and his subsequent indefatigable research in connection with the subject. As the result of his investigations the following list was compiled, in which each element or gas is electro-positive to all those which follow:—

(+) Metals which decompose water
Hydrogen
Carbonic oxide
Phosphorus
Sulphur
Alcohol
Ether
Olefiant gas
Ethereal oils
Camphor
Metals which do not decompose water
Nitrogen
Carbonic acid
Nitric acid
Oxygen
Peroxides
Iodine
Bromine
Chlorine

The principle of the gas battery consists in substituting gases for the solid electrodes in a voltaic cell, the said gases, by their reaction one upon another and the electrolyte, having the effect of generating a current, available at the terminals of the cell, which latter usually take the form of metallic or carbon plates, immersed partly in the gas and partly in the electrolyte.

One of the most recent attempts to apply the principle of the gas battery to the solution of the problem indicated in

the title of this article was that of Dr. W. Borcher's. His cell at first consisted of an outer glass or stoneware containing vessel, divided into two compartments communicating with each other at the bottom. In this vessel was placed an ammoniacal or acid solution of cuprous chloride; air was supplied to one compartment and carbonic oxide to the other. The electrodes were both of carbon, and yielded only a very weak current when connected.

An improvement on this form was shortly afterwards effected by substituting a copper electrode for the carbon in the carbonic oxide compartment. Coal gas also took the place of carbonic oxide, whilst acid solutions were found to give better results than those of an alkaline nature. By using the last-described form of apparatus, the external compartments being filled with copper turnings, a maximum electromotive force of 0.56 volt was obtained, and, on short circuit, the cell was found to give 0.64 ampère. In a later form of this battery the outer containing vessel was constructed of copper and formed one of the electrodes. The inner cell was of perforated earthenware.

It was estimated that with Dr. Borcher's gas battery at least 27 per cent. of the fuel consumed is converted into electrical energy. Unfortunately, however, recent investigations tend to show that the evolution of a current from this type of cell is due rather to the solution of the valuable copper electrode than the desired carbon or coke, thereby discounting its apparent value in this connection.

The great difficulty met with in the practical application of the gas battery principle consists in the fact that the current-producing capacity of the cell depends on the rate of occlusion of the gases by the electrodes employed. This occlusion, for all practical purposes, requires electrodes of an impracticable area, though it is possible that the preliminary storage of the gases under pressure might effect a saving in this direction. Researches in this field should, therefore, tend to the discovery of an electrode material which is capable of absorbing large volumes of gas, and, at the same time, giving up such gas when required for reaction in a gas battery. The discovery of such a material would greatly extend the scope of the gas battery problem.

Summing up the various data so far available, it is fairly obvious that the final solution of the interesting problem of producing electrical energy directly from coal does not lie with the first three methods, which, as already noted, involve the preliminary generation of heat energy on a wasteful plan. The matter, therefore, lies, so far, with the voltaic cell in which carbon is the consumed electrode and the gas battery, and it is just possible, though hardly probable in the immediate future, and under present known scientific conditions, that either of these methods, or a successful combination of the two, may provide us with a scientific solution. On the other hand, it must be remembered that the apparatus will probably prove cumbersome and costly, so that although the theoretical efficiency might be as high as 70 or even 80 per cent., the great interest on capital outlay would probably be a prohibition to its commercial adoption.

THE ORIGINAL, ILL-FATED "MAINE" ENTERING THE HARBOUR OF HAVANA, WHERE SHE WAS BLOWN UP IN FEBRUARY, 1898

BATTLESHIPS OF THE UNITED STATES NAVY

By Naval Constructor H. G. Gillmor, U. S. N.

IN the minds of many the terms battleship and warship, or vessels of war, are regarded as synonymous, and before attempting to describe the battleships of the navy it is desirable to point out that, while the term warship, or vessel of war, includes all types of vessels built for war purposes, the term battleship is used only when referring to one of the many types,—and that the most important,—that help to make up the navies of the recognised naval powers.

Technically, the battleship might be defined as a vessel of war in which, with a moderate speed and good coal-carrying capacity, there are combined heavy armour protection and the heaviest armament. The offensive and defensive qualities are developed to such proportions that the ship may not only inflict great injury, but may itself sustain much injury without being destroyed or disabled. To accomplish these ends, it is necessary that a battleship should carry a very heavy battery, and that the area and thickness of the armour carried should be as great as possible. This, necessarily, involves large weights, and the battleship has, therefore, in all stages of the development of naval vessels, been the heaviest of all the types. Ideas as to what are a desirable speed, what a suitable coal capacity and battery, and what the necessary features of protection have varied, and the dimensions and characteristics of battleships have changed correspondingly.

The earliest vessels of the battleship type to be added to what has been termed the New Navy of the United States were the historic *Maine*, blown up in Havana harbour in 1898, and the *Texas*. To-day they seem to lack many of the qualities now deemed essential in battleships, but at the time that they were projected they represented the advanced ideas of the day for vessels of that type.

For several years after the construction of these two vessels had been authorised no provision was made by Congress for vessels of the battleship type. In the meantime ideas in battleship design had developed rapidly, and when, in 1890, about four years after authorising the building of the two ships in question, Congress provided for the construction of three battleships, vessels greatly superior in all respects to the *Maine* and *Texas* were projected. They were the *Indiana*, *Massachusetts*, and the *Oregon*. With them it may be said that the construction of the American battleship began. The general features of these vessels, modified to a greater or less degree, are to be found in all battle-

THE "OREGON'S" RUNNING FIGHT AT SANTIAGO

FROM A PAINTING BY FRED PANSING

ships of the navy; and in order to give a comprehensive idea of the completed vessels of this type, the first will be described in more detail, and the modifications which have been introduced in later vessels in any or all of the features will be brought out.

The characteristics of many of the harbours on the United States coasts have made it necessary to limit the draughts of ships of the Navy to about 24 feet, and all of the American battleships have been designed with this draught. The contract requirements for speed in the above-mentioned three vessels was placed at 15 knots, but there was a provision in the contract by which the builders would receive a bonus at the rate of $25,000 for each increase of speed of one-quarter of a knot above the contract requirement. They are, as are all vessels of this class, propelled by twin screws, driven by two engines, the steam for which is supplied by cylindrical boilers of the Scotch type. The lowest speed, that of the *Indiana*, was 15.547 knots as a mean speed for a trial of four hours over a measured course, the indicated horse-power developed being 9738. At the time of her trial the ship had been nineteen months out of dock, practically all of the time in fresh water.

The *Massachusetts*, by the same builders, made, on trial, 16.21 knots, with an indicated horse-power of 10,415, and the *Oregon's* trial speed was 16.79 knots, with an indicated horse-power of 11,111. Both of the last two vessels earned substantial bonuses for their builders, and all three have demonstrated their ability as good steaming vessels in all weathers. The coal bunker capacity is about 1600 tons, enabling them to make long voyages, such as that made by the *Oregon* in her famous passage from San Francisco to Key West prior to, and during the early months of, the late Spanish war, without the necessity of receiving coal frequently.

UNDER THE 12-INCH GUNS ON THE "IOWA"

The general ideas in arrangement, calibre, and system of mounting followed in these vessels have served as a basis from which the armament of all the later vessels have developed. They have each four 13-inch guns, mounted in

MARINES DRILLING ON THE "KENTUCKY"

pairs in two turrets, one forward and one aft, giving an arc of fire of about 270 degrees for each pair of guns. The turrets, guns, and mounts of these vessels form a moving weight of about 490 tons, the centre of gravity of which is not coincident with, but about 3½ feet from, the axis of rotation. This lack of balance of the turret system increases some of the difficulties in connection with train, etc., in a seaway, and is, in some degree, a defect which has been remedied in the designs of all later turrets. These turrets have steam training gear and hydraulic elevating gear.

There are also eight 8-inch guns, mounted in four turrets at the four corners of the superstructure, the guns being mounted in pairs in the turrets, which are raised about one deck height above the turrets for the 13-inch guns, so that they have a clear fire above the heavy guns. These 8-inch turrets have steam training gear, and the elevation is effected by hand. The vessels were designed as coast-line battleships, and the freeboard or height of the upper deck at the ends of the vessel is less than in later battleships, so that the command of the 13-inch guns is less by about one deck height. In addition to the 13-inch and 8-inch guns, there are four 6-inch guns, two on each side between the 8-inch turrets. The secondary battery consisted of twenty 6-pounder and six 1-pounder rapid-fire guns, mounted on the superstructure and bridges and in the fighting top of the single military mast of the vessel.

TAKING IN AMMUNITION ON THE "KENTUCKY"

The 13-inch turerts carry 15-inch armour, and the turret gear and ammunition supply are protected by a barbette, extending up from the protective deck and carrying 17-inch armour. The 8-inch turrets carry armour 6 inches thick, and the barbettes for the protection of their turning gear and ammunition service have armour 8 inches thick in the front and reduced to 6 inches in the back. The four 6-inch guns are protected by 4-inch armour.

INSPECTION ON THE "IOWA"

For the protection of the water-line there is a belt of armour, 7 feet 6 inches wide, extending between the two barbettes. The thickness of the upper 4 feet of width of armour is 18 inches; below this it tapers to 8 inches at the bottom. Diagonal bulkheads are worked across the vessel at the ends of this belt, the thickness of the armour upon which is 14 inches.

The protective deck over the portion of the ship having a water-line belt is worked horizontally at the level of the top of this armour, and has a uniform thickness of 2½ inches of nickel steel, oil-tempered and annealed. From the ends of the water-line belt the protective deck is given transverse curvature and slopes toward the bow and stern and protects the entire ends, its thickness over these portions being 3 inches.

For further protection against loss of stability by injury of the ends of the vessel there are cofferdams on each side, 3 feet in thickness, extending a considerable distance above and below the load water-line, in which corn pith cellulose is packed. When these cofferdams are penetrated by shot this cellulose expands, by its own elasticity and by swelling by the absorption of the water, closes the hole, and prevents the ingress of water. Above the main water-line belt there is a shorter belt of 4-inch armour with diagonal bulkheads of the same thickness, extending between the ends of this belt and the barbettes, forming a central casemate for protection of the ammunition supply to the 6-inch guns and the secondary battery.

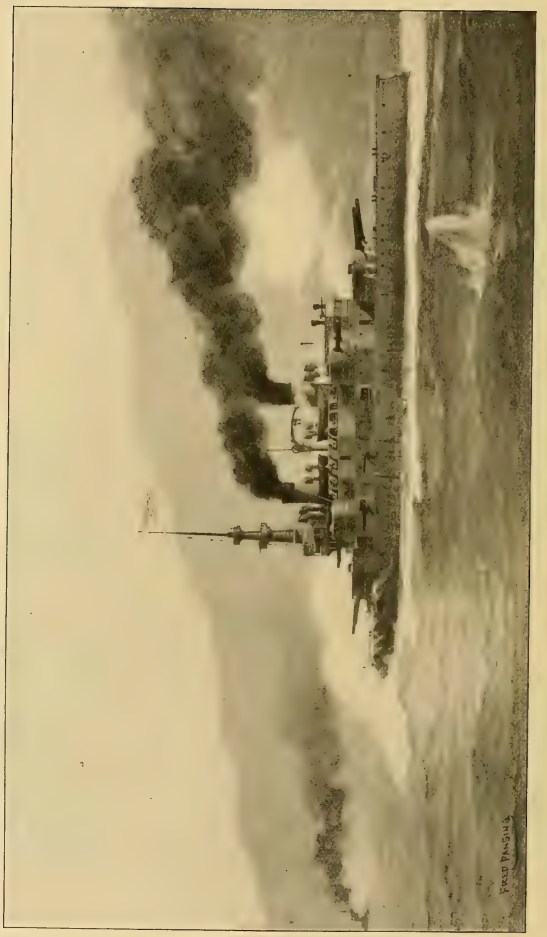
The vessels were designed with a load water-line length of 348 feet, a beam of 69 feet 3 inches, and have a full-load displacement of about 11,400 tons. The contract price for the hull and machinery of the *Indiana* and *Massachusetts*, exclusive of bonuses, was $3,063,000, and that for the *Oregon*, $3,222,810. The contract for the *Massachusetts* was signed on November 18, 1890; her keel was laid on June 25, 1891; she was launched on June 10, 1893; and was commis-

sioned on June 10, 1896. The contract for the *Indiana* was signed on November 19, 1890; her keel was laid on May 7, 1891; she was launched on February 28, 1893; and was commissioned on November 20, 1895, almost exactly five years after the date of her contract. The contract for the *Oregon* was signed on November 19, 1890; her keel was laid exactly one year after that, on November 19, 1891; she was launched on October 26, 1893; and put in commission on July 15, 1896.

The construction of the *Iowa*, the next of the battleships, was authorised by Congress in July, 1892. While the design of the *Indiana*, *Massachusetts* and *Oregon* served as a basis for the design of the *Iowa*, considerable changes were introduced. The designed speed was increased to 16 knots, the general type of the machinery and boilers remaining as in the first-named vessels, with an increase in the designed horse-power to 11,000. The coal capacity was also increased about 200 tons, to 1800 tons. The ship, on trial, notwithstanding the fact that there were no bonuses for extra speed, made 17.087 knots as a mean of four hours, running over a measured course, her machinery developing, under the trial conditions, 12,105 horse-power.

The chief difference in the armament of this vessel, as compared with its predecessors, is in the calibre of the heavy guns, 12 inches having been fixed upon as the calibre of the heavy turret guns instead of 13 inches, their number and arrangement remaining unchanged. The form of the turrets in which these guns are mounted is so modified in the *Iowa* as to produce absolute balance about the axis of rotation, so as to remove some of the difficulties inherent in the unbalanced turrets. The freeboard of the vessel, forward, was increased in the *Iowa* by one deck height, so that the command of the forward pair of 12-inch guns is correspondingly increased. In the number and position of 8-inch guns there was no change, except that the four turrets for the 8-inch guns were brought closer together in the fore-and-aft direction. The raising of the forward 12-inch guns one deck

WARDROOM ON THE "KENTUCKY"



"CLOSING IN." THE "OREGON" AT THE BATTLE OF SANTIAGO

FROM A PAINTING BY FRED PANSING

height brings the 8-inch guns on the same height with the 12-inch guns.

The turret-turning and gun-elevating gears, for both the 12-inch turrets and the 8-inch turrets, are of the same general design as in the *Indiana*, *Massachusetts*, and *Oregon*. In place of the four 6-inch guns installed on the vessels just described, the *Iowa* was given six 4-inch guns. Practically no change was made in the arrangement and number of the guns of the secondary battery, excepting that four Colt automatic guns were substituted for two 1-pounders.

THE 12-INCH AND 8-INCH GUN TURRETS ON THE "IOWA"

The arrangement for the armour protection of the 12-inch and 8-inch guns for this ship is practically the same as that of the *Indiana* and her class, except that the maximum thickness of armour on the turrets of the *Iowa* is 15 inches instead of 17 inches. The 4-inch gun positions are protected by 4-inch armour. In the extent and arrangement of the water-line and diagonal armour this vessel differs from her predecessors only in that the thickness for the upper 4 feet of the width of the armour is 14 inches, the remaining portion tapering to 7 inches, as against 18 inches maximum thickness and 8 inches at the bottom for the *Indiana* and her class, and the diagonal bulkheads 12 inches in thickness instead of 14 inches. In the casemate armour practically no change was made. The 4-inch gun sponsons are protected by 4-inch armour. The protective deck features are identical with those of the earlier ships.

The increase in speed and freeboard involved increased dimensions of the ship, and she was designed with a load water-line length of 360 feet, and breadth of 72 feet 2½ inches, and has a full-load displacement of about 12,445 tons. The contract for the construction of the hull and machinery of the vessel, at a cost of $3,010,000, was signed with the William Cramp & Sons Ship and Engine Building Company on February 11, 1893; the keel was laid the fifth of the following August; she was launched on March 28, 1896; and was commissioned on June 17, 1897, about four years and six months after the date of her contract.

For nearly four years after authorising the construction of the *Iowa* no provision was made for building battleships. On

THE "KEARSARGE." SHOWING FORWARD SUPERPOSED TURRETS

March 2, 1895, Congress authorised the construction of two additional battleships, which were afterwards named the *Kearsarge* and *Kentucky*. The designed speed of these vessels was the same as that of the preceding vessels, and their machinery and boilers were of the same general character. The maximum bunker capacity was, however, reduced to 1400 tons. The *Kearsarge* made, on trial, 16.816 knots, developing 11,954 horse-power; and the *Kentucky*, 16.897 knots, developing 12,318 horse-power.

Although in many respects similar to the vessels described above, the designs for the *Kearsarge* and *Kentucky* involve such novel features in arrangement of battery, when compared with all previously constructed or projected vessels of this class, as to excite the interest and attention of the naval world to an extent that probably no others of the United States battleships have. For some time before the designs for these vessels were prepared the feasibility had been much discussed of superposing, upon the turrets for the heaviest guns of the battleships, smaller turrets to mount a pair of 8-inch guns, moving with the main turret, so as to utilise the armour protection of the heavy turret for the protection of the ammunition supply of the 8-inch guns, and, at the same time, permit all-round fire of the 8-inch guns on both beams without interference with the larger guns. Many arguments were advanced for and against the proposed system, and a considerable difference of opinion developed as to the balance between the advantages and disadvantages.

It was finally decided to install in these two vessels the superposed turrets. Thirteen-inch guns were chosen for the heavy guns. Four of the eight 8-inch guns, which battleships up to that time had been designed to carry, were omitted, and the remaining four were placed two in each of the two turrets, superposed upon and secured to the main 13-inch turrets so as to move with them. The motive power for the turret

gear was at the same time changed from steam to electricity. A broadside battery was also introduced, made up of fourteen 5-inch guns, mounted seven on each side amidships between the two barbettes, and having a broadside fire only.

These guns are on an open deck behind side armour, and are only partially separated from one another by 2-inch nickel-steel screen bulkheads, placed vertically between immediately adjacent guns. Four additional 1-pounders were added to the guns of the secondary battery carried by the *Iowa*, and the arrangement of this battery was somewhat modified. The ships were provided with two military masts instead of the one fitted in the vessels described above.

The disposition of the armour of the heavy guns is the same as that of the earlier vessels, but the thickness of the armour-plating is increased to a maximum of 17 inches on the front of the turret, tapering to 15 inches at the back. The maximum thickness of the barbette armour is unchanged, but the armour at the back of the barbette, where protected by the casemate, is considerably thicker on these vessels than it is on the *Iowa*. The superposed 8-inch turrets are protected by armour 11 inches in thickness at the front, tapering to 9 inches at the sides and back.

The extent of the water-line belt is very much increased by carrying it forward from the forward barbette to the stem. The portion of this belt between the barbettes is of the same width and length, relatively, as in the earlier vessels, but tapers in thickness uniformly from 16½ inches at the top to 9½ inches at the bottom of the belt. The portion of the water-line belt from the forward barbette to the stem is reduced in thickness by steps, in going forward, to a minimum thickness of 4 inches at the stem.

The diagonal bulkheads at the ends of the heavy armour belt are disposed in these vessels as in their predecessors, but the thickness of the armour of the forward armoured bulkhead is 10 inches, and that of the after bulkhead, 12 inches. The general arrangement of the protective deck is the same as in other vessels of this class, and the thickness of the horizontal portion on a level with the top of that portion of the armour between the barbettes is 2½ inches. Aft, however, where there is no side armour, the sloping sides of the protective deck are made 4 inches in thickness, and the thickness of the flat is 1½ inches; forward, behind the side armour, the thickness of this deck on the slopes is 2 inches, and on the flat, 1½ inches.

Above the water-line belt, casemate armour, one deck in height, is fitted, the thickness of the armour being 4 inches. For the protection of the broadside battery, this casemate armour is carried all the way up to the upper deck. The armour on this portion is 6 inches thick, with diagonal armoured bulkheads 5 inches thick at the ends of this upper belt.

In general dimensions the *Kearsarge* and *Kentucky* differ from the *Iowa* only by an increase of 8 feet, to 368 feet in length, with a corresponding increase of about 200 tons in designed displacement. The contract for the construction of these two vessels was signed with the Newport News Shipbuilding and Dry Dock Company on January 2, 1896, the cost of the hull and machinery of each being $2,250,000. Their keels were laid on the same day, June 30, 1896; and they were launched on the same day, March 24, 1898. The *Kearsarge* was commissioned on February 20, 1900, and the *Kentucky* on May 15, 1900.

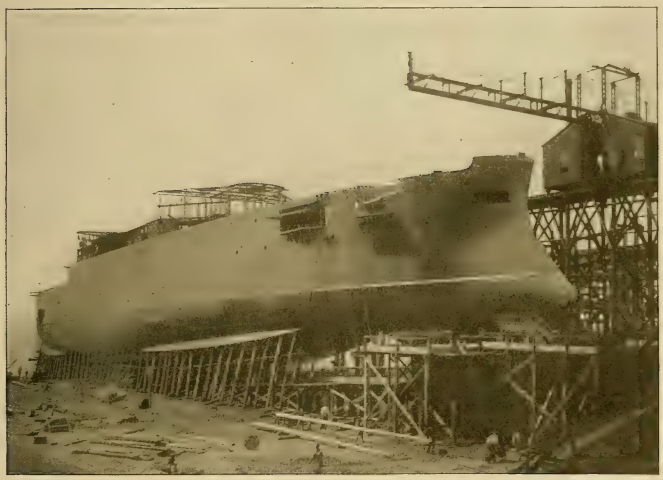
On June 10, 1896, less than one year after authorising the construction of the *Kearsarge* and *Kentucky*, Congress authorised the construction of three more battleships, to be named *Alabama*, *Illinois*, and *Wisconsin*. In general dimensions, displacement, speed, coal capacity, and general design of machinery and boilers these vessels are practically the same as their immediate predecessors, the *Kearsarge* and the *Kentucky;* in the character and arrangement of the battery, however, they differ very greatly from those vessels. They were designed for a speed of 16 knots. The *Alabama* made, on trial, 17.103 knots,

THE "ILLINOIS" AT FULL SPEED

with 11,366 horse-power; the *Illinois* 17.449 knots, with 12,898 horse-power; and the *Wisconsin* 17.174 knots, with 12,322 horse-power.

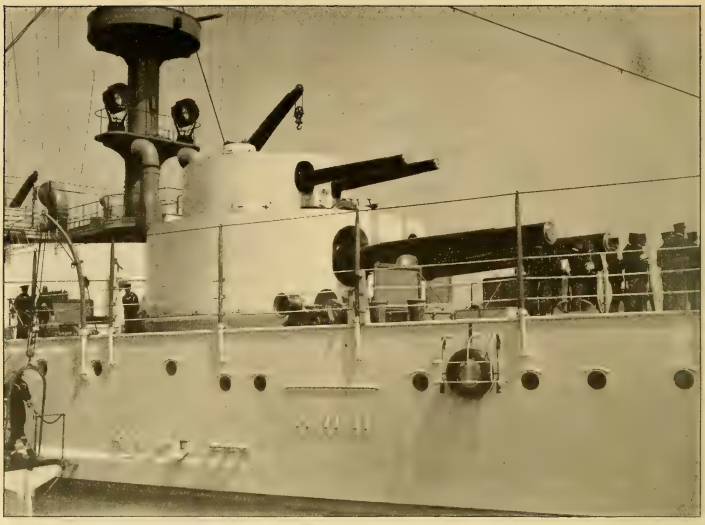
The 8-inch guns and superposed turrets of the *Kearsarge* and *Kentucky* are omitted entirely in these three later ships; and as compensation for this omission, instead of 5-inch guns, 6-inch guns, fourteen in number, are installed. The battery space, which in the *Kearsarge* and the *Kentucky* is taken up by fourteen 5-inch guns, is, in these latter vessels, devoted to eight 6-inch guns, mounted four on each side, to form a broadside battery. These guns, like the 5-inch guns on the *Kearsarge* and *Kentucky*, are mounted on an open deck behind armour, and are separated only by short splinter bulkheads of 2-inch nickel-steel between adjacent guns, partially enclosing them. Immediately above the gun-deck battery there are four 6-inch guns, mounted two on each side amidships, providing for beam fire only. The remaining two 6-inch guns are in armoured sponsons, forward, on the gun deck, and have bow fire. The secondary battery differs from that of the *Kearsarge* and *Kentucky* only in the omission of the four 6-pounders and two 1-pounders, necessitated by the mounting of the four 6-inch guns on the main deck.

The water-line protection and end-armour bulkheads in extent and arrangement are identical with those of the *Kearsarge* and *Kentucky*. The case-mate armour is also the same, extending for two deck heights between the barbettes. In the *Alabama* and her sister vessels, however, the upper belt, forming the protection for the broadside battery, is 5½ inches in thickness instead of 6 inches. For the protection of the four 6-inch guns mounted amidships on the main deck there is 6-inch armour immediately in front of these guns, and the armour on the sponsons of the two 6-inch guns mounted forward on the main deck is also 6 inches in thickness.



THE "ILLINOIS" READY FOR LAUNCHING IN THE YARD OF THE NEWPORT NEWS SHIPBUILDING AND DRY DOCK CO., NEWPORT NEWS, VA.

The general dimensions of the *Alabama*, *Illinois*, and *Wisconsin* are the same as those of the *Kearsarge* and *Kentucky*, namely, length, 368 feet; beam, 72 feet 2½ inches; and full-load



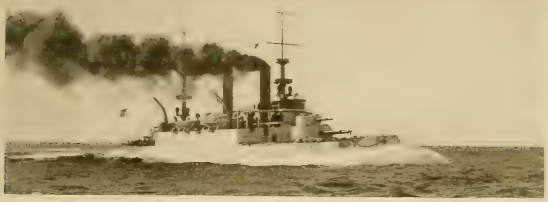
ONE OF THE SUPERPOSED TURRETS OF THE "KEARSARGE"

displacement, 12,170 tons. The contract for the *Alabama* was signed with the William Cramp & Sons Ship and Engine Building Company on September 24, 1896, the price named for hull and machinery being $2,650,000. The contract for the *Illinois* was signed with the Newport News Shipbuilding and Dry Dock Company on December 20, 1896, the price for hull and machinery being fixed at $2,595,000. The contract for the *Wisconsin* was signed on September 19, 1896, with the Union Iron Works, of San Francisco, and the price was fixed at $2,674,950 for hull and machinery. The keel of the *Alabama* was laid on December 2, 1896; she was launched on May 18, 1898; and was commissioned on October 16, 1900. The keel of the *Illinois* was laid on February 10, 1897; she was launched on October 4, 1898; and was commisisoned on September 16, 1901. The keel of the *Wisconsin* was laid on February 9, 1897; she was launched on November 26, 1898; and was commissioned on February 4, 1901.

All of the vessels described have been completed, and are now in service. While presenting minor differences, they are, in the main, of strikingly similar general characteristics, so that, considered as a division of a fleet, they possess that homogeneity upon which so much stress is laid by naval tacticians. There is a difference of a little more than one knot of the speeds shown on trial. The essential features of armour and of protective decks are the same in all, but the extent and amount of protection varies somewhat among them. The armour for all is of nickel-steel, treated by the Harvey process, and of American manufacture. The most important differences are in the armament, 12-inch and 13-inch guns being both employed for the heaviest calibre guns of the battery, and 8-inch and 5-inch and 8-inch and 6-inch combined, and 6-inch alone, for second-calibre guns.

There are under construction for the navy eight other battleships, three of which, the *Maine*, *Missouri*, and *Ohio*, are well advanced toward completion; and five, the *Georgia*, *Nebraska*, *New Jersey*, *Rhode Island*, and *Virginia*, are

in the early stages of construction. It is not intended here to give a description of these vessels. Suffice it to say that on account of their increased size and speed, the use of water-tube boilers and of Krupp armour, they mark a considerable step ahead in battleship design, and they will, when finished, form another division of the battleship fleet, homogeneous in itself, but differing considerably from those which have been described above and now in commission.



THE "KENTUCKY" ON TRIAL

THE WORK OF THE ENGINEER

By James Mansergh, Past Pres. Inst. C. E.

IT has long been impossible for any individual to give adequate expression to the fullness of the combination of contemporary science, art, knowledge and practice which we recognise for engineering. Engineers, as the writer maintained in an address before the Glasgow International Engineering Congress, constitute more than a profession; they amount to a "race," and it is upon them, more than upon any other class of the civilised world, that falls the heaviest share of the "white man's burden."

There have been framed many definitions of engineering and of the engineer, but none that I can esteem adequate and at the same time sufficiently exact and exclusive. My reason for holding this opinion is based on two considerations. The first is the persistence of much popular ignorance of the nature of our work, and some lack of appreciation of our class; and the second is the stubborn refusal of the English spirit to admit the necessity of any formal qualification on the part of those who claim to be of the profession. With us,—odd as such a state of things may seem to our more highly organised foreign colleagues,—an engineer may hold a diploma, or he may not. He may be entitled to append a string of capital letters to his name, or he may not possess a single title to nominal distinction. This is because engineering with us does not consist in being, but in doing.

The public's unformed, vague idea of an engineer is that of a man who can do things,—a great and constantly increasing number of things,—all falling within a wide but fairly recognised category. His quality seems to lean more to the side of invention than to that of scholarship. For my part, I am content to have it so. Not that an engineer can ever be too deeply instructed, or too well trained in all the elements of knowledge and skill required for the effective pursuit of his calling; but the really great engineer is born, not made.

So subtle is the influence of words upon thought that I could wish the name of our avocation were spelt in English,

as it is in languages of more pronounced Latin derivation, with a capital "I" instead of "E,"—"Ingeniering," say, in place of "Engineering." Thus the nature of our work would be better recognised among the people, who are careless of etymologies. The suggestion of the name would be removed from association with the word "engine" (a good enough one in its degree, and one that has a wider significance than is now left of it), and would be placed where it rightly belongs, with the root idea which gives us the words "ingenious," "ingenuity," and others.

We must, however, go no further in this direction for the missing definition of engineering or we shall get into the clouds, where, although I am not sure but that we might find some colleges of engineering, we should miss the substance of the thing itself. For engineering is the only high art which depends as much on its cheapness for its excellence as upon any other item in the sum of its achievement.

All other things being equal,—adaptability, soundness, efficiency,—the engineering work which costs the least money is the best. I do not know of any other product of man's creative powers of which the same can be so truly said. The "cash" basis is the real foundation upon which the engineer builds, and this consideration draws us at once from judging engineering as merely something cleverly done by an ingenious person. It also very often serves to distinguish between college, text-book, or rule-of-thumb engineering and the real thing.

At any rate, it places in due prominence a quality which those who regard engineering studies from the college standpoint are apt to ignore. I have heard a legend of a professor of applied mechanics who was shocked at the thought of steam engines being made to sell for money,—like cakes. A good deal of wasted ingenuity would be saved if those who engage in every kind of engineering work would remember to use the money standard, as well as the foot-rule and the higher mathematics.

Real engineering must be mastered as it is realised on works in progress. It has no authoritative text-book. The working engineer's library is sometimes largely composed of ephemeral manufacturers' catalogues and lists of prices current of materials. Like the perfect artist described by Longfellow, the engineer must learn to work with the means that lie readiest to his hand. He must cherish his ideals or he will sink into the routineer, but he, of all men, cannot afford to indulge in hobby riding. He leaves as little as possible to chance, and, if he is wise, he will not rely upon his best mathematics any further than he can see them. If he starts with aptitude, plods on with patience, observes with insight, records with careful exactitude, and adapts with wisdom, in the fullness of time he will find himself, almost to his surprise, in possession of judgment, and that is the glory of an engineer, fitting him for his highest employ as man-of-all-work to civilisation.

Material civilisation owes much to this faithful servant. Others may plot, scheme, invent, discover wants and their proper supplies; the engineer, as a rule, does chiefly what he is told wants doing. By strict attention to his own business he helps to make the crooked ways straight and the rough places plain for all. The engineer must have great power for concentration. His solicitude is to make every job a little better than the last. The newest steam engine shows a fractional economy of steam; the latest steamship carries her freight with a scarcely distinguishable saving in coal consumption per ton; the selected railway metal lasts a little longer than the previous purchase; the main line is straightened here and there; and, incidentally, as it were, the remote ends of the earth are brought closer together, and plague, pestilence, and famine are driven back.

The wiseacres who declare on political platforms that the effect of modern civilisation is to make the rich richer and the poor poorer forget all about engineering. The engineer is the chief of the modern democratic civil service.

ELECTRIC STORAGE BATTERIES

By Arvid Reuterdahl, Sc. B., A. M.

THE economical nature of the world has always demanded that a maximum amount of energy should become potential, and, as such, be in complete subjugation to man, only awaiting his mere wish in order to become kinetic and do the useful work which he desires. In accordance with this economic law of Nature man has, since the earliest times, attempted to provide for himself means whereby energy might be collected and stored for future service. Hence it is only what we should expect that the advent of electricity should also bring forth attempts at collecting and storing it. In the fullness of time, therefore, the modern electric storage battery made its appearance, as a result of that ever-active economic law which strives for universal advancement.

The basic investigations which are the foundations of the modern accumulator are to be traced back to the days when electricity was in its infancy. The phenomenon of polarisation was observed by Humboldt as early as 1796. In a letter written by Humboldt to Dr. Ash, of Oxford, on April 10, 1796, he described the action which takes place when a moistened zinc plate is brought into contact with a plate of silver. He also referred to a similar action between other metals when in the presence of water. Humboldt also pointed out the fact that water was decomposed into oxygen and hydrogen, and he was the first to use the term "decomposition of water by galvanic action."

It was on the basis of these observations that Volta was able to announce his famous law on November 7, 1801, and perfect the pile and the so-called "Crown of Cups" which was the forerunner of the present voltaic cell.

In the year 1799 Ritter carried the observations of Humboldt still further. Gautherot, in 1801, observed that after platinum and silver, in the presence of a salt solution, had been subjected to the action of a primary charging current, the combination, after removal from the solution, was capable of generating a short secondary current in the opposite direction. Erman, Davy, and Marianini added somewhat to the knowledge of the subject.

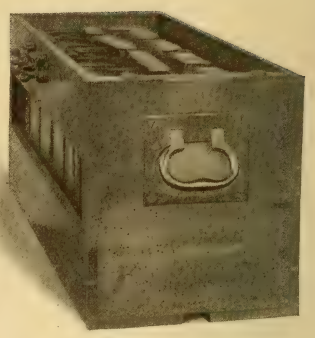
Schoenbein, in 1837, found that peroxide of lead could be used in secondary cells, and Sir William Grove learned that oxidised metallic plates were suited for the purpose. Siemens and Wheatstone discovered the value of peroxide of lead for such oxidation, and Michael Faraday observed that peroxide of lead was formed at the positive electrode, while metallic lead was formed at the negative pole when lead acetate was decomposed by electrolysis.

It was in 1860 that Planté constructed the first practical storage cell, which consisted of two spiral sheets of lead separated from each other by canvas. The electrolyte was a 10-per cent. solution of sulphuric acid. These plates were rendered active by "forming,"—a process which consisted of exposure to from twenty to thirty charges of electricity, the direction of the current being reversed frequently. Between each of these charges the cell was completely discharged. The positive plates under this treatment assume a deep brown colour, due to the production of peroxide of lead, and the negatives show a greyish-blue colour, due to the forma-

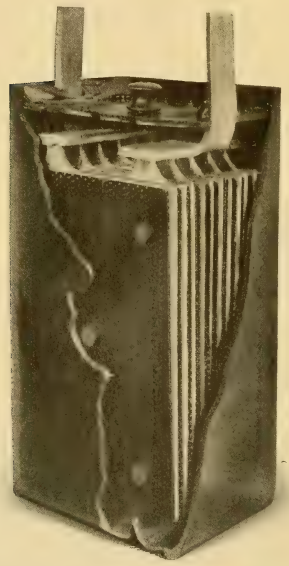
tion of "spongy" lead. These two chemicals constitute the "active material" of this type of storage cells.

Since Planté's time various types have been devised. They are (1) the lead-lead type; (2) the lead-zinc; (3) the lead-copper; (4) the alkaline-zincate; and (5) a type which the author has called "constant concentration" cells.

Everyone has some vague idea of what is meant by a storage battery. The popular conception pictures a storage battery as some kind of reservoir or receptacle into which electrical energy can be put and from which it can be taken out as desired. According to this notion, a storage battery is entirely analogous to a glass which can, at pleasure, be filled and emptied. The water can be poured into or out of the glass either quickly or slowly without in any way injuring the glass. The only limitation or restriction which is connected with this notion is that of a definite and maximum capacity. This crude and popular analogy, however, does not correctly represent the case.



A BATTERY FOR LAUNCH PROPULSION



A MODERN AUTOMOBILE CELL

A storage cell is primarily an inert contrivance from which an electric current can be obtained, upon the condition that its constituent parts be so modified by a charging current that they be made capable of independent generative activities. The cell is an electrical machine from which a secondary discharge current can be obtained, providing a primary charge current from some external source has previously been sent through.

Being an electrical machine, it is subject to the limitations of all machines. It must receive proper care. Like human beings, it must be given the right quantity and quality of nutriment. If it is overtaxed continuously, disease and death will follow. Its energy output is not equal to, but is less than, the input.

The principles involved in the ordinary primary cell are well understood by everyone. In order to comprehend the activities which take place in a secondary or storage cell we should have clearly before us what takes place in the ordinary primary cell. We find two classes of conductors in all primary cells. The first class serve as electrodes, and conduct, like metals; and the second class are solutions of one or more electrolytes. Every primary cell must contain both of these constituents.

Primary cells may be divided into two classes,—constant and inconstant cells. A constant element is one in which the

electromotive force does not change while the cell is in action, while an inconstant element is one in which it does. The condition which must be fulfilled by a cell in order that its electromotive force shall remain constant is that the inner processes occurring in the cell during its action shall remain unchanged.

If the electromotive force of a constant element is not changed by the passage of a current in a direction opposite to that of normal flow, it is said to be "reversible." This is possible only when the cell's nature or inner mechanism is unchanged by the reverse current. The most common illustration of this is the case of electrodes immersed in solutions of their own salts.

Where this is the case, the reverse current deposits a definite quantity of one metal and dissolves a corresponding quantity of the other metal. When a reverse current is thus passed during a short period of time the element remains entirely unaltered in its nature.

The other class of constant elements in which the electromotive force is changed during the passage of a reverse current is called "irreversible." It is theoretically possible to use any reversible cell as an accumulator or storage cell. This would be accomplished by merely passing through the element a reverse current, that is, one which is opposite in direction to that of normal flow when the element is closed. Innumerable practical difficulties, however, appear in the case of most reversible elements, and these are accountable for the slow progress which has been made in the storage battery field.

The constituent parts of the ordinary storage cell are, — the element, the liquid or electrolyte, and the containing jar or tank. The element consists of plates which contain what is called "active material." These plates are divided into two groups, one set being called positives, the other negatives. All the positives are connected to one bus-bar, while the negatives are connected to another and separate bus-bar. There is generally one more negative plate than there are positive plates in a cell.

The liquid, or electrolyte, as it is called technically, in the common type of storage cell, is generally a dilution of sulphuric acid to a specific gravity of about 1.2, which corresponds to 1200 on the hydrometer. The containing jar is generally of glass, earthenware, hard rubber, or celluloid, or it may consist of a wooden tank lined with lead. A storage cell is often called a secondary cell or an accumulator. More than one cell electrically connected constitutes a storage battery.

THE LEAD BATTERY

The plates of the Planté type of battery are formed from metallic lead by successively reversing the charging current, while in the Faure type of plates the active material is not formed by the electric current from the metal itself, but is mechanically applied in the form of spongy metallic lead, or of a lead oxide, or of some insoluble lead salt, to a lead plate. The original Faure patent is dated January 11, 1881.

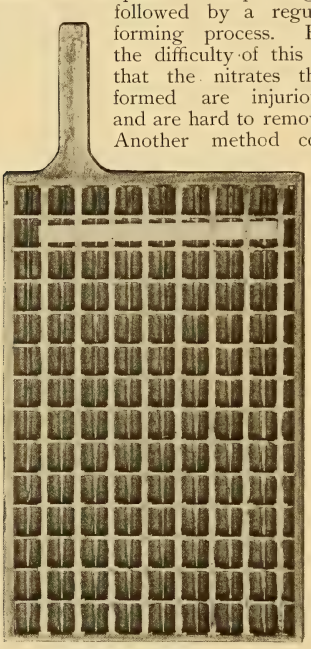
Without going minutely into the chemical changes which take place within a lead-lead cell, it may be stated that the action of the charging current is practically to convert lead sulphate or oxide into metallic or spongy lead at one pole, and into peroxide of lead at the other. During the discharge of the cell both the spongy lead at the one pole and the peroxide of lead at the other pass over into sulphate of lead in the presence of sulphuric acid.

This so-called spongy lead is not, as often supposed, a finely divided metallic lead, but is an allotropic form of lead, possessing peculiar properties. Its conversion into metallic lead is accompanied by the evolution of heat. The electromotive force produced by the combination of a peroxide or positive plate in dilute sulphuric acid with finely divided metallic lead is considerably less than that produced when opposed to electrolytic or spongy lead.

The Planté process of formation is very tedious, as can be seen from the fact that modern practice advocates about thirty charges in each direction, with an intermission between each re-

versal. To complete the entire operation requires about two months.

A great many methods, a number of which are kept as trade secrets, have been devised to reduce the time element in the Planté forming process. In general, a process of pickling in nitric acid is used, and a layer of lead oxide is formed on the plate. This pickling is followed by a regular forming process. But the difficulty of this is, that the nitrates thus formed are injurious, and are hard to remove. Another method consists in the electrolytic deposition of spongy lead and its subjection to pressure. This is then converted to peroxide.



GRID FOR AN AUTOMOBILE CELL

In the Faure system, the paste is generally made from minium, or red lead, for the positives, and litharge for the negatives, combined with sulphuric acid. The paste on the positive plates becomes, under the action of sulphuric acid, Frankland's red lead salt. The paste on the negative becomes Frankland's buff lead salt. The conducting supports to which the paste is applied generally consist of plates of lead containing perforations, grooves, or recesses, and are commonly called "grids." The plates, after being grouped into elements, are formed in dilute sulphuric acid, through the action of an electric current, for a period of from twenty to thirty hours. Peroxide of lead appears on the positives and spongy lead on the negatives.

The advent of modern electro-chemistry has thrown new light upon the subject of the storage battery. The resultant efforts of such men as Arrhenius, Van't Hoff, Nernst, Faraday, Helmholtz, Hittorf, LeBlanc, Raoult, and Ostwald have been to put the marvellous and previously inexplicable phenomena of electrolytics on a rational and scientific basis. Through the work of these men the fruitful conception of the "ion," or charged atom, or group of atoms, has been clearly defined and shown to be a product of electrolytic dissociation.

As a consequence of these discoveries we are able to show that the chief source of the electromotive force of a secondary or storage cell lies in the passing of quadrivalent lead ions, each carrying four charges of electricity, into bivalent ions which carry two charges of electricity. The peroxide of lead furnishes the quadrivalent ions which pass over into bivalent ions, and form, with sulphuric acid, sulphate of lead. At the anode, metallic lead is dissolved, forming lead ions which convey the positive electricity into the solution from this pole. Then these lead ions combine with the SO_4 ions of the sulphuric acid to form lead sulphate.

From this standpoint, charging consists merely in the transformation of bivalent lead ions into quadrivalent ions; while discharging consists in a counter transformation of quadrivalent lead ions into bivalent ions.

The voltage or electromotive force of a single, fully charged lead-lead cell on an open circuit, about two minutes after the end of the charge, is 2.2 volts. This soon falls somewhat. During discharge the voltage falls continuously. The dis-

charge should generally be stopped at 1.75 volts per cell, but some allow discharge to 1.5 volts. The working range is, therefore, from 2.2 to 1.75 volts.

It is customary to state the normal capacity of a cell in ampère-hours, based upon the current which it will deliver when discharged at a constant rate for eight hours. Thus a cell which will discharge at 10 ampères for eight hours without the voltage falling below 1.75 volts is said to have a capacity of 80 ampère-hours. It does not follow that 80 ampères would be secured if the cell were discharged in one hour. It is safe to say that not more than 40 ampère-hours would be the result with this rapid discharge. The ampère-hour capacity decreases with the increase in current output. An 80 ampère-hour cell, capable of delivering 10 ampères for eight hours, would, when discharged at 14 ampères, have a capacity of 70 ampère-hours; when discharged at 20, its capacity would be 60; and when discharged at 40, its capacity will have decreased from 80 to 40 ampère-hours. Generally speaking, the voltage during discharge is an indication of the quantity of electricity remaining within the cell.

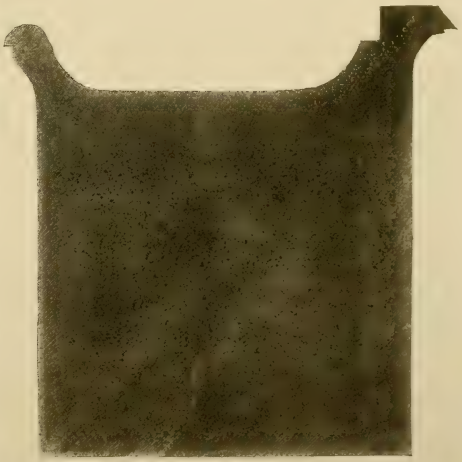
Complex activities must take place during charge and discharge. If the electrolyte is tested with an hydrometer, it is found that the specific gravity of the solution varies directly as the state of charge or discharge, so that the reading of the hydrometer indicates the quantity of electricity which the cell can deliver at the time. The temperature of the room may enter into the problem as the specific gravity decreases with increase in temperature.

If an hydrometer be allowed to float in the electrolyte of a storage cell during both charge and discharge it will soon be apparent that the density, or specific gravity, of the liquid varies continuously and directly with the state of charge or discharge. In other words, the increase or decrease in specific gravity of the electrolyte during charge or discharge is practically proportionate to the percentage of ampère-hours put in or taken out of the cell.

The specific gravity of a certain cell was observed to fall from 1.21 to 1.18 while being completely discharged. When 50 per cent. of its capacity in ampère-hours had been taken out, the specific gravity was about 1.195. On completely charging this same cell, the specific gravity rose proportionately with the charge from 1.18 to 1.21, thus illustrating the direct variation.

These observations were taken with a practically constant room temperature. Should the surrounding temperature vary, corrections in the readings to allow for this must be made, as the specific gravity of the electrolyte decreases with increase in temperature. Here, then, is another valuable indication of the condition of the cell's active material and of its degree of charge.

The specific resistance of the elec-



AN ELECTRO CHEMICALLY FORMED PLATE BOTH FACES OF THE PLATE HAVE BEEN COMBED INTO INNUMERABLE THIN LEAVES IN ORDER TO INCREASE THE SURFACE. THIS TYPE OF PLATE IS USED EXTENSIVELY FOR CENTRAL AND POWER STATION SERVICE

trolyte itself is also subject to change. Furthermore, the cell temperature varies with charge and discharge, falling during discharge and rising during charge. This may be partly accounted for by the well-known fact that the addition of sulphuric acid to water raises the temperature, and hence it can be inferred that its removal from the water will lower the temperature. As the specific gravity of the electrolyte falls during discharge, this certainly indicates a removal of sulphuric acid, which, therefore, bears out the previous assertion in regard to the cause for fall in temperature.

It is pretty evident that the alterations in the structure of the plates themselves must be very complex to account for the many and intricate modifications which occur within the cell regarded as a unit. The active material during charge and discharge undergoes chemical change irregularly, not merely in different plates, but in different parts of the same plate. In the same plate the internal resistance in one part of the active material is sometimes greater and sometimes less than in another part, varying with the unequal chemical action. Actual differences of potential between parts of the active material itself cause continual and detrimental local action.

The potential of a cell is due partly to the degree of charge of the positive and partly to that of the negative, and partly also to the state of the electrolyte. Hence, it follows that a measurement of the voltage at the terminals of a cell is not an infallible indication of its condition of charge. If both plates are equally charged, the indication is valuable, but when this is not the case, as often occurs in actual practice, the potential difference is very deceptive.

Erroneous ideas concerning the so-called surface of an accumulator plate are often met with among engineers. Generally speaking, the effective or unfolded surface of an accumulator plate is not the product of its length and breadth, but must be determined from more complex considerations. If this were not the case, discharges obtained from Faure or pasted plates would certainly be unexplainable when compared with Planté plates.

The effective or unfolded surface of a Faure plate is not simply the product of its two dimensions, but depends upon the porosity of the plate and the relative position of the active material to the neighbouring parts of the conducting support or grid. Dr. Konrad Norden has suggested an ingenious way of ascertaining the unfolded or real surface of an accumulator plate by means of an oxalic acid electrolyte.

Without doubt the question has often been asked, "Why are storage batteries generally made from lead and salts of lead?" It would seem that no poorer selection of a metal for a storage battery could possibly be made. Why not make use of such a light metal as aluminium, or, at least, of some metal whose electrical conductivity is good?

In answer to these queries it may be briefly stated that other metals are dissolved by the electrolyte, while lead is practically insoluble on account of the formation of insoluble lead sulphates which surround the metallic conductor. The writer can do no better than cite the following from a paper on "The Chemical Theory of Accumulators," by E. J. Wade: —

"Herein lies the superiority of a lead-lead peroxide cell to all others. If properly treated, it may be regenerated electrolytically, and so nearly to its original chemical and physical condition that it can be charged and recharged in this way hundreds and even thousands of times before the total results of the slight changes that do take place depreciate it sufficiently to incapacitate it for further use, while with all other cells the changes that occur with each charging are relatively so large that, although all possible means have been tried to reduce them to a minimum, the cells rapidly deteriorate, and require constant attention and repairs.

"The reason for the more complete reversibility of a lead cell is entirely due to the chemical behaviour of certain of the compounds into which the metal enters. Lead alone, of all the metals, forms a sulphate that is practically in-

soluble and unacted upon in water and dilute sulphuric acid; the lead sulphate, which is the ultimate product formed at the poles, does not dissolve in the solution, but remains on the surface of the plates ready for reduction and reoxidation when the current is reversed.

"Any local action that goes on when the cell is not at work also results in this insoluble sulphate, which tends to form a protective coating on the metal, and thus reduces losses from this cause to a minimum. The compounds formed, when other metal than lead is used as the negative, not necessarily in a sulphuric acid electrolyte, but in any other practically possible solution, are all soluble, and dissolve in the liquid as fast as they are formed, and this simple fact has, up to the present, barred the way to any substantial progress with these classes of reversible cells."

Notwithstanding these bold and strong assertions of Mr. Wade, there is still hope that, with a more thorough understanding of electro-chemistry, proper combinations of metals and electrolytes will be made which will satisfactorily solve these difficult problems. Encouraging results have been obtained recently through the use of lighter, but more expensive, metals, than lead.

Turning our attention more particularly to the large stationary cells used in isolated plants and stations, cells in which weight does not enter as a consideration, let us ask ourselves,—What elements are necessary to constitute an ideal lead-lead storage cell?

The author would say, in reply, that an ideal lead-lead storage cell should satisfy the following conditions:—

1st.—Its plates should be made integrally from chemically pure and dense rolled sheet-lead whose molecular structure and density is uniform throughout, thus reducing local differences of potential to an absolute minimum.

2nd.—The ratio of the real or unfolded contact surface to the apparent surface should be the greatest compatible with the largest output during the longest life.

3rd.—The plates should be as completely reversible as possible, insuring the maximum reduction of the peroxide to lead sulphate during discharge, thus preventing its superoxidation and consequent softening which would result in the "shedding" or falling of the peroxide material.

4th.—The active material should possess the maximum attainable porosity, and should be distributed over the greatest possible surface in such thin layers that complete reversibility in the minimum time can take place.

Where these conditions are fulfilled, both efficiency and life are increased, due to the small work necessary per unit area, together with a reduction in the internal resistance. These desiderata are practically fulfilled by the so-called grooved, spun, sawed, or combed plates turned out by several different makers.

Although the lead-lead type of battery is commonly thought of as a most ponderous method of storing energy, actual facts show that it is, without exception, the lightest practical reservoir of power in use to-day. Compressed air, for example, yields, weight for weight, only 27 per cent. of the energy obtained from a modern lead-lead storage battery.

In view of the complex changes which occur in the constituents of a storage cell, the writer would suggest that vastly superior results can be obtained from batteries if charging is discontinued when the voltage has reached a point between 2.3 and 2.45 volts, and if discharging is stopped when the voltage has fallen to about 1.95 or 1.9 volts. Within these limits practically no injurious reactions and activities occur, and hence both life and efficiency are increased and regulation becomes simplified.

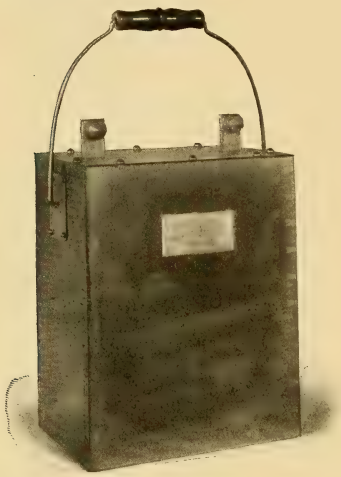
OTHER FORMS OF STORAGE BATTERIES

Passing on to the consideration of the other forms of storage batteries, we come to the lead-copper type. Cells of this type possess the advantage of being simple and economical to manufacture. They retain their charge fairly well, but on account of their low voltage, which averages about 1.25 volts, and their

small capacity per unit weight, they are not extensively used.

The lead-zinc type is interesting on account of its high difference of potential of about 2.5 volts. There are two ways of increasing the power output of a cell, —either by increasing the ampère-hour capacity or by increasing the voltage. The lead-zinc type is designed to increase the capacity of storage cells by augmenting their voltage.

The difficulties liable to arise in this form of cell are clearly seen from a consideration of the activities which take place. When a lead-zinc cell is being discharged, the positive electrode becomes deoxidised, but the zinc electrode is attacked by the electrolyte, and a part of it is taken into the solution. When recharging, the opposite actions occur, and the dissolved zinc is redeposited upon the zinc electrode. It will, therefore, be readily seen that the success of this type of cell depends upon three things,—the absence of any solution of the zinc when the cell is on open circuit, the regularity of the solution and redeposition of the zinc from and upon the negative, and the certainty of obtaining a solid and strong deposit of zinc on the negative electrode.



A PORTABLE STORAGE BATTERY. CAPACITY, 60 AMPÈRE-HOURS. PRESSURE, 8 VOLTS

Irregularity of solution and deposition really constitute one of the greatest troubles in this form of cell. There is a great tendency for the zinc to be dissolved more rapidly at one part of the negative surface than at another, and for it to redeposit at other points than those from which it has been removed. For this reason the shape and outline of the electrode becomes considerably changed and ultimately goes to pieces.

Reynier, in 1883, attempted to construct a scientific lead-zinc accumulator which should overcome the difficulties already pointed out. His positive plates were ordinary peroxidised lead plates of the Planté type. The negatives, however, were made from thin sheets of metallic lead, having upon their surfaces an electrolytic deposit of zinc. They were amalgamated by arranging on their surfaces leaden pockets holding small quantities of mercury. The electrolyte consisted of a solution of zinc sulphate.

At first this cell gave good results, but Reynier overlooked the fact that no matter how well amalgamated the negatives were kept, metallic lead forms a couple with metallic zinc, and hence his cell was doomed to destruction. Curiously enough, however, copper, if kept continuously amalgamated, does not seem to form a couple with metallic lead. In this fact, therefore, we have a clue toward the construction of a practical lead-zinc cell.

The fourth type of cells is the alkaline-zincate. As the name indicates, one of the electrodes consists of zinc, while the electrolyte is some alkali of the type of potassium hydrate, ordinary caustic potash or sodium hydrate, commercially known as caustic soda. Among this class of cells may be mentioned the Desmazure, Edison-Lalande, Lalande-Chaperon, and Waddell-Entz accumulators. These are, as a general rule, of extremely low voltage.

The constituents of the Desmazure cell are a positive plate produced by compressing copper mud under a pressure of 1000 atmospheres into blocks, covered with brass gauze, surrounded

by a parchment wrapper; a negative, consisting of iron gauze; an electrolyte, consisting of water, zinc, combined potash and free potash; and finally a containing vessel of tinned sheet-steel. The voltage of this cell is only 0.8 volt. The Edison-Lalande accumulator has copper oxide as one electrode, and almost anything that can be plated with zinc for the other, the electrolyte being caustic potash.

Still one more type of accumulator is to be considered. As this class of accumulator has not, up to the present time, received a name, the author has designated it "constant concentration cells."

In the United States this type of cell has become known on account of its intimate connection with the name of Edison. The assertions and claims for this cell in the sensational daily papers have, as is usually the case, been preposterous. Statements were made that the Edison cell contains metals and chemical compounds hitherto unknown to science. Such assertions, however, must be taken with a grain of salt. Notwithstanding the exaggerations of cheap journalism, this type of cell is both scientifically interesting and replete with merit.

The Edison cell is not, however, a radical departure or anything absolutely new in the storage battery field. Nickel was used in storage cells as early as the year 1885 by Dun. Desmazure, in 1887, used electrodes of porous nickel.

In 1889 Michalowski invented a new process of making nickel electrodes. He was the first to call attention to the thermo-chemical properties of nickel, which make this metal especially adapted for positive electrodes. Compounds of iron were used in 1896 by Pollak for both the positive and negative electrodes. Accumulators employing this form of plates are made by the "Accumulatorenwerke System Pollak," of Frankfort, Germany, and are claimed to be very solid and to have high capacity. In the manufacture of these plates iron powder or compounds of oxygen with iron are compressed while wet, and are then heated so that they come into a porous but solid state. The electrodes are then formed in an alkaline electrolyte like caustic soda. The Pollak cell is of the constant contentration type.

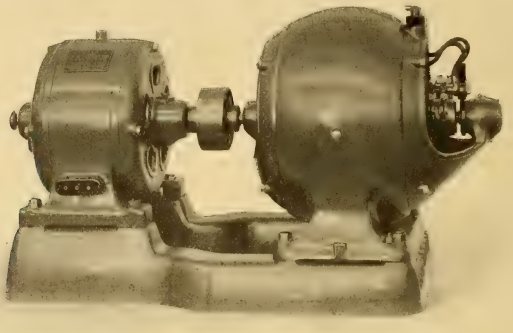
In 1896 Krieger patented a cell using nickel. Jungner, of Stockholm, Sweden, produced, in 1898, two varieties of constant concentration cells, one based upon copper and the other on cadmium and silver. The earlier form of the Edison cell employed copper and cadmium as electrodes in an alkaline electrolyte. Edison claims that in this cell the initial and final states of the electrolyte are the same. Hence this variety evidently is a constant concentration cell.

From a paper read lately by Dr. A. E. Kennelly before the American Institute of Electrical Engineers, we learn the following facts concerning Edison's iron-nickel cell:—Both the positive and negative plates are made from thin sheet-steel, about 0.024 inch in thickness, out of which rectangular holes are stamped so as to leave a grid or frame somewhat resembling a window frame. Each opening or recess is filled with a shallow box containing the active material. These boxes are made of thin, perforated crucible steel, about 0.003 inch in thickness. They are filled with active material which is made in the form of rectangular cakes or briquettes. A small cover of perforated crucible steel is then applied to each little box. Both the small boxes and the steel grids are nickel-plated.

The briquettes for the positive plates are made by mixing a finely divided compound of iron with a nearly equal volume of thin flake graphite. The mixture is pressed into briquettes in a mould, under a hydraulic pressure of about two tons per square inch. The surface area of each briquette is nearly three inches by one-half inch on each face.

In a similar way the negative briquettes are produced by mixing a finely divided compound of nickel with a nearly equal bulk of fine flakes of graphite and solidifying the mixture under pressure in a mould. The little perforated and covered boxes which contain the active material are then

placed in the openings in the nickel-plated steel grid. The assembled plate is next placed in a hydraulic press and subjected to a total pressure of about 100 tons. This pressure not only tightly closes the boxes, but it also forces their metal sides over the adjacent sides of the holes in the steel grid.



A STORAGE BATTERY BOOSTER SET CONSISTING OF AN 8½ H. P., 104-VOLT, SINGLE-PHASE INDUCTION MOTOR COUPLED DIRECTLY TO A 100-VOLT GENERATOR

The chemical actions which take place in the Edison cell during discharge seem to be of precisely the same general nature as those which take place in all other constant-concentration cells. During the discharge the positive plate is reduced from a higher state of oxidation to a lower one, and the negative plate is oxidised from a lower state of oxidation to a higher one, while the chemical composition of the electrolyte is not changed. The entire action seems to consist in the lifting of one atom of oxygen through a given potassium hydroxide ($K\ O\ H$) or potash solution from one electrode to the other. Charging pulls the oxygen away from the iron and delivers it temporarily to the nickel. The condition of the cell is then stable until the circuit of the cell is completed. Discharge then allows the oxygen to fall back from the nickel to the iron because of the natural affinity of iron and oxygen.

The concentration of the electrolyte in the Edison cell, when taken as a whole, is constant, or, in other words, its specific gravity remains the same during both charge and discharge. This interesting cell gives a relatively low discharge voltage. The initial voltage of discharge after recent charge is 1.5 volts. The average voltage of full discharge is approximately 1.1 volts.

THE REGULATION OF STORAGE BATTERIES

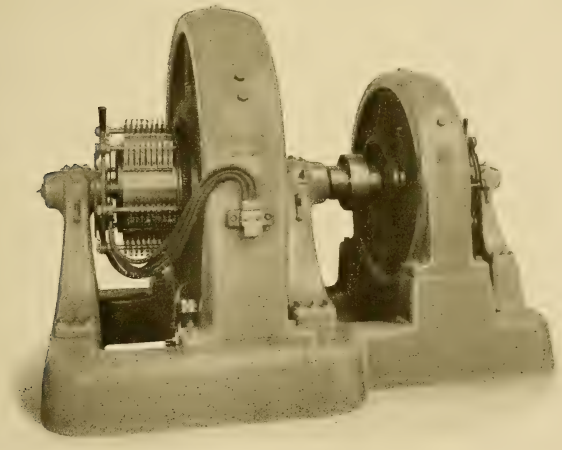
Taking up the second portion of the subject, which refers to the regulation of storage batteries, the writer refers, of course now, to the lead-lead storage battery as operated in conjunction with generating plants. Even a momentary consideration of the variations in voltage during charge and discharge shows that some means are necessary for regulating these changes in order that a desired constant voltage may be obtained.

Suppose, for illustration, we take a practical example! It is desired, say, in a certain isolated plant, to operate fifty 110-volt, 16-candle-power incandescent lamps either from a generator or from a storage battery. It is also desired that provisions be made for charging the battery while the lights are fed at their proper potential. Evidently when the storage battery has reached its lowest allowable discharge voltage of, say, 1.8 volts per cell, the aggregate

battery voltage ought to be just sufficient to provide for a difference of potential of 110 volts at the lamp terminals.

A simple example in division will determine the number of cells necessary to maintain the proper lamp voltage at lowest battery voltage. Dividing 110 by 1.8, we obtain 61 for a quotient, which is then the number of cells which must be connected in series to establish the desired 110 volts at the lamp terminals.

So far, this is simple enough, but the difficulty will begin when we consider the charging of the battery. When charging a storage cell it establishes a current will flow from battery to generator, with a tendency to run this as a motor. If a voltmeter reading be taken at the terminals of a fully charged cell while the charging current is still flowing, it will indicate a difference of potential of about 2.5 volts. It is customary to charge a storage cell until this charging difference of potential is attained per cell. This means that in order to fully charge the 61 storage cells the generator must be able to generate an E. M. F. of at least 61 times 2.5 volts, or 152.5 volts. It would, however, on the one hand, be disastrous to attempt to operate the 110-volt lamps with such a high



A BOOSTER SET CONSISTING OF A 150 H. P., 525-500-VOLT, SHUNT-WOUND MOTOR COUPLED TO A 115-180-VOLT DIFFERENTIALLY WOUND GENERATOR

counter electromotive force. The charging current will, in every case, equal the quotient obtained by dividing the difference of the impressed E. M. F. and the counter E. M. F. by the resistance of the battery. This shows us that in order that current may flow into the battery the impressed E. M. F. must be greater than the counter E. M. F. If the numerator reduces to zero, current will flow neither in nor out of the battery. If the counter E. M. F. becomes greater than the impressed E. M. F., generator E. M. F.; while, on the other hand, it would be impossible to charge the storage battery if the generator E. M. F. were not increased above 110 volts.

There are, generally speaking, four methods which may be used for overcoming these difficulties:—1st—By the use of equalising rheostats; 2nd—By the use of counter E. M. F. cells; 3rd—By the employment of regulating cells; and 4th—By means of "Booster Systems."

In brief, the first method consists gen-

erally in dividing the cells into two branches or groups in parallel on charging, providing a switch which will, on discharge, connect the two branches in series. Each branch is provided with what is called "an equalising rheostat," which is some form of a variable resistance. When a current flows through these rheostats there will be a definite fall of potential within them, depending upon the amount of resistance cut in or out and also upon the current strength. The rheostats must be made of such capacity that there will be sufficient fall in potential in them at normal current to neutralise the excess in voltage of the fully charged battery above that of the lamp voltage.

This system allows the accumulators to be kept in circuit and charged and discharged equally. This greatly reduces the attention required to manage the battery, and would be a decided advantage in a small plant. The plan, however, involves waste of energy in dead resistance, though this would not amount to much in a small installation.

Another objection to the introduction of resistance into the circuit is the variation in voltage which it occasions, with changes in the current strength. A resistance of 0.1 ohm, for example, causes a drop of two volts when the current is 20 ampères; but if it increases to 100 ampères, owing to the turning on of more lamps, the drop would then become ten volts, and the effective potential would fall eight volts, which would greatly diminish the light of the lamps.

To overcome this difficulty the second system, which consists in using counter electromotive force cells, is employed. These consist of simple lead plates or grids without active material, and immersed in dilute sulphuric acid. The counter electromotive force set up by these cells is practically constant, and independent of the value of the current. Their internal resistance being very low, the drop due to it is small; hence, they produce an almost constant reduction in the voltage of a battery with which they are connected in series in order to bring down its potential during the first part of the discharge. They are cut out, one by one, as the electromotive force of the battery falls, thus keeping up the effective pressure.

The third method consists in using what are known as reserve, regulating, or end cells. These cells are successively cut in or out of the circuit, adding or subtracting their electromotive force to the aggregate battery electromotive force. During discharge the battery voltage falls. Hence, these cells are successively switched into the circuit.

The switching devices which are used in connection with such cells are known as end-cell switches. It is customary to use two such switches, one employed during discharge, the other during charging. The contact pieces of these switches must be made in such a way that they do not short-circuit the cells as they pass from one point to the next. This is accomplished by splitting the movable contact arm into two parts, between which a certain amount of resistance is introduced, so that when the two parts happen to rest on two adjacent contact points the resistance prevents the cell which is connected to these two points from being short-circuited, and also avoids breaking the circuit.

The fourth and final method of regulating storage batteries is by what are called "Booster Systems." The term "booster" is used to signify a dynamo-electric machine driven in any suitable way and used for the purpose of generating an auxiliary electromotive force which may be either added to or subtracted from the battery electromotive force.

Booster systems are classified as series, shunt, compound, differential, and constant current. It is well known that the electromotive force of a dynamo depends upon three things only:—1st, the armature speed; 2nd, the number of armature conductors; and 3rd, the field strength. Therefore, practical methods of varying the electromotive force of a dynamo must be based upon the variation of the armature speed or upon the change in field strength. The operation of all booster systems depends upon this fact.

STORAGE BATTERY APPLICATIONS

The function of accumulators is to receive electrical energy at one time or place, and to give it out at some other time or place. The efficiency of an accumulator is not 100 per cent., but, as in all other machines, there is some loss in transforming. The average ampère-hour efficiency of an accumulator is about 90 per cent., while the energy or watt-hour efficiency is lower,—about 80 per cent. in most storage cells.

The principal uses to which accumulators may be put are the following:—

1st.—General portable use, including traction and launch work, where a large capacity is desired in a small space.

2nd.—To prevent and equalise fluctuations in either voltage or current due to unsteadiness in such sources of energy as the wind-mill, gas, or gasoline engines.

3rd.—To enable the machinery to be stopped during certain portions of the day or night. The advantage of this application depends upon the fact that in almost every electric lighting plant there are long periods during the day and late at night when the number of lamps lighted is so small that it may not pay to run the generating machinery.

4th.—To carry the peak of the load with a gain in economy

5th.—To maintain uniform load on engines. Steam engines are very inefficient at light loads. This inefficiency, in fact, is one of the chief sources of loss in an electric lighting plant, and the principal object of the engineer who designs and operates a station should be to reduce this waste to a minimum. The accumulator is the most important means of accomplishing this result. Doubtless an accumulator would benefit any plant in which an engine runs for a considerable portion of the time at less than half its full power.

6th.—Accumulators may be used as transformers. If the cells of a battery are arranged in series while being charged, and in parallel for discharging, a high-voltage current will be required for charging and a low-voltage current will be given out.

7th.—They may be used for subdividing the voltage. The most important practical case is that in which a dynamo of 220 volts charges a battery of corresponding potential, a three-wire system being supplied from the battery, the neutral wire of which is connected to the middle point of the battery. This arrangement avoids the necessity of running two dynamos, and allows the battery to be placed in a sub-station near the districts to be supplied, so that it is only necessary to run two conductors to that point instead of three.

8th.—The storage battery may be used as a "floating battery" in order to reduce the drop at the end of long feeders, due to heavy currents flowing over the line for a short period of time, and also, in a measure, to relieve the power station fluctuations.

9th.—To enable current to be supplied from local centres or sub-stations. The plan of installing battery plants at local centres which are charged from the main station enables some of the conductors to be saved in a three or five-wire system. It also makes it possible to reduce the size of these conductors, because the current which flows over them can be kept practically constant, so that it is not necessary to have them large enough to carry the maximum current consumed by the lamps which may be several times the average value.

The writer has in these pages attempted to set forth the evolution of the modern storage cell from its simple origin, the galvanic element. Great advancement has certainly been made towards the production of a good storage cell, but the present age is not easily satisfied; its standards and ideals are lofty, and the goal is, therefore, difficult to attain. The consensus of public opinion has practically formulated the requirements of the future ideal storage cell as follows:—

It should be light and compact; inexpensive; practically indestructible; efficient; capable of high rates of charge and discharge without injury and loss of efficiency; and capable of retaining its charge indefinitely.

The ultimate problem of the investi-

gator in this field finally reduces itself to that of obtaining a large percentage of the total energy from carbonaceous fuel. The present source of electrical power is practically through the chain work of the boiler, steam engine and dynamo. The boiler gives an average return of about 70 per cent. of the heat put into it. The average dynamo may return as much as 90 per cent. of the energy put into it. This would give a combined efficiency of about 63 per cent., which is not a bad figure. Yet when the prime mover, the steam engine, is added, the combined efficiency of all three is often as low as 10 per cent.

If we compare this with the efficiency of such a material as zinc when oxidised in a battery, we realise the uneconomic nature of the process. About 90 per cent. of the energy of oxidation of zinc is transformed into electrical energy in the ordinary primary cell. This most valuable characteristic of zinc does not, however, bring us any nearer the solution of the problem, as zinc is comparatively expensive, and is itself produced remotely and indirectly by means of carbonaceous energy. On this account most attempts to reach the goal have been based upon the assumption that electrical energy ought to be obtained directly from carbonaceous fuel.

The conditions which must be satisfied for the construction of a successful carbon cell similar to the ordinary zinc cell are that carbon should be dissolved in a non-oxidising electrolyte, and that carbon or its equivalent should be oxidised at the other electrode by an oxidising electrolyte.

The production of such a cell is extremely difficult because air, the only practical oxidant, is a gas, and carbon monoxide and carbon dioxide, the products of the oxidation of carbon, are gases.

A brief calculation of the possible output of a carbon cell based upon these principles may be interesting. The oxidation of carbon to carbon dioxide is accompanied by the production of 96.96 calories, or 24.25 calories per gram equivalent. This, when reduced to its equivalent, gives 96540. coulombs at a pressure of 1.04 volts. The maximum electromotive force of a cell which oxidises carbon by air is, therefore, about 1.04 volts.

Zinc, on the contrary, when oxidised in a similar way, generates a current at a pressure of about 1.86 volts. From this comparison it may appear that carbon is inferior to zinc for this purpose. Nevertheless, when we compare the total electrical energy obtained, the vast superiority of the carbon cell is clearly evident. A kilogram of carbon produces 8080 calories, as against 1329 calories for the same amount of zinc. A unit weight of carbon, therefore, gives six times as much energy as an equal weight of zinc. As zinc is at least twenty times as expensive as carbon in the form of coal, we could obtain a given quantity of energy from coal at about $\frac{1}{120}$ of the cost of the same quantity of energy from zinc, the same efficiency being assumed.

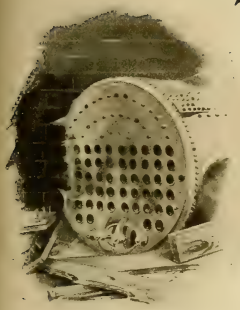
Ostwald has well defined the nature of the ideal carbon cell. "The carbon cell of the future," he says, "should have the oxidising agent in the place where the carbon is not." This oxidising agent must be either the oxygen of the air or some carrier of it. This kind of cell will operate in a manner entirely analogous to the ordinary furnace. Coal will be put in on one side while air is introduced at the other, the products being energy and carbon dioxide. An electrolyte which is not permanently affected or changed must be placed between the coal and the oxygen in order that it may be used continuously to oxidise the carbon electrolytically.

He who attempts the solution of this most intricate problem must arm himself with the perseverance of the ancient alchemists who grew gray and old while searching for the elixir of life and the philosopher's stone. He need not despair, however, as in this complex world of atoms there are possible innumerable combinations of atoms, and, therefore, the probability is large that at least some one combination will satisfactorily solve the problem of constructing this ideal cell of the future.

WASTE HEAT ENGINES

RESULTS OF RECENT BINARY ENGINE TRIALS

By George H. Barrus



THE best economical results which have been obtained from the ordinary type of multiple expansion engines, using either dry steam or steam which is slightly superheated, are represented by a consumption of about eleven pounds of steam per indicated horse-power per hour. With highly superheated steam, this figure drops to ten pounds, or possibly a little lower.

When it is reported, therefore, that a steam engine of 170 H. P. capacity has been operated with only 8.25 pounds of steam per I. H. P. per hour, and that with large powers this may be reduced to a still lower point, engineers will wonder how such a result has been accomplished, and whether it can become an everyday performance. This low figure is reported in a pamphlet written by Prof. Josse, of the Royal Technical High School, of Berlin, Germany, and describing the apparatus and the experiments during the progress of which the result noted was obtained, the experiments having been made in the mechanical laboratory of that institution. Whether the means employed to obtain this superior economy can be made use of in practical service, is a matter for commercial demonstration. The report and the experiments bear the marks of reliability, and they are worthy of study and discussion.

The engine is of the "binary" type, that is, it consists of two parts. The first of these uses steam in the ordinary way, while the second employs a different fluid, this being of such a nature that it vaporises at a low temperature; in fact, at so low a temperature that the heat of the steam exhausted from even the condensing cylinder of a steam engine is sufficient to evaporate the fluid into a vapour possessing a high pressure; and the second part of the engine is made to utilise the power of the vapour thus generated.

Numerous attempts have been made in the past to introduce binary engines for commercial purposes, but, so far as the writer is informed, none of these have passed much beyond the experimental stage. Among the fluids which have been employed for the secondary, or waste heat, part of the engine may be mentioned sulphuric ether, bisulphide of carbon, and aqua-ammonia. The writer is personally familiar with the use of only one of these fluids for motive power, namely, aqua-ammonia, having conducted, several years ago, a series of investigations upon a small, experimental plant employing ammonia vapour. The engine in this case was a simple, non-condensing engine, and it used the ammonia vapour direct. It cannot be included in the class of binary engines which are here considered, but it demonstrated the fact that no practical difficulties existed in the use of vapours for producing power other than steam, at least none in the case of ammonia.

An excellent review of the theory of binary engines and the practical results obtained with them was prepared by the late George H. Babcock, and published in the Transactions of the American Society of Mechanical Engineers, Vol.

VII., the paper being entitled " Substitutes for Steam." According to Mr. Babcock, and others who share the same views, it seems to have been pretty generally held that there is, theoretically, single-expansion engine, which is not in itself of the most economical type. The theory regarding the possible advantage of binary engines has been based on the results obtained in cases of this kind

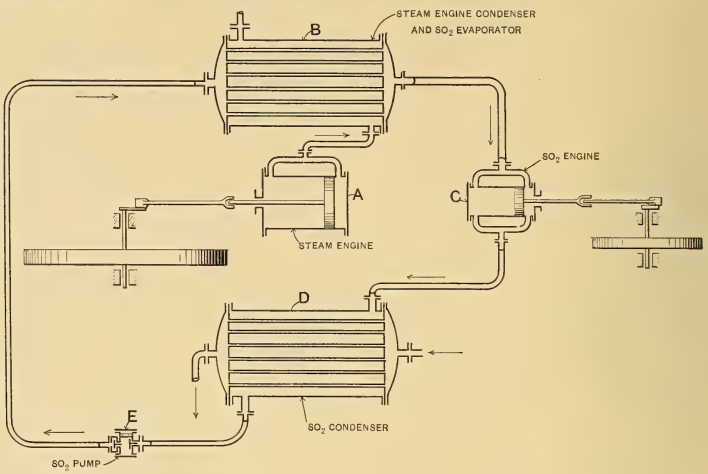


FIG. I.—DIAGRAM OF A SULPHUROUS ACID ENGINE

no superior economy possible in a binary engine beyond what is attainable in a steam engine, provided the steam engine is designed and operated to its best advantage. The improved results that have apparently been shown in favour of the binary engine are explained on the ground that advantage has been taken of wasted heat for running the secondary engine, which heat could just as well have been employed in a steam engine alone, if suitably designed. Suffice it to say that no binary engine seems to have attained so great economy in steam consumption as the best type of engine using steam alone, and this fact seems to have heretofore justified the views of these theorists.

In the earlier types of binary engines, the waste heat, if the writer mistakes not, was derived from steam exhausted from a non-condensing engine,—a type of engine which is not in itself economical. Moreover, the primary engine was one having a single cylinder, that is, a where the primary engine is of itself a wasteful engine. It is only by inference that the theoretical effect of applying the binary principle where the engine is already of the most economical type could be determined, for no data of such combinations had been obtained when Mr. Babcock and others advanced these views.

The system described by Prof. Josse, contrary to those heretofore brought out, applies to a steam engine already of the most economical type; that is, a triple-expansion engine, working condensing and supplied with steam which is superheated. In this engine the addition of a secondary cylinder worked on the binary principle produced one-third as much power as the original amount developed by the steam engine, and thereby secured a reduction of 25 per cent. in the quantity of steam consumed by the entire plant per I. H. P. per hour. We are, therefore, confronted with the fact that even in a modern

steam engine of the most economical type the binary principle may be applied with marked advantage, thus overturning the theories heretofore advanced.

In the engine described by Prof. Josse the fluid used for the secondary cylinder is sulphur dioxide (SO_4), commonly known as sulphurous acid. It is claimed by Prof. Josse that this is a safe vapour for the purpose; but, at the same time, to attain success, certain precautions must be observed in using it. Among these it may be remarked that the stuffing boxes about the cylinders must be specially designed to prevent the escape of the vapour into the surrounding air, because its odour is offensive, and the gas is injurious if breathed into the lungs. Owing to the action of the acid upon brass, the use of brass fittings about the cylinders must be avoided. The acid is a lubricant itself, and consequently no further lubrication is required.

Sulphurous acid, like other fluids of its class used for this purpose, is peculiarly adapted to the binary engine, owing to the low temperature at which vaporisation takes place. At the temperature of ordinary condenser overflow water, say, 104° F., the sulphurous acid vapour has a pressure of ninety-one pounds absolute, or seventy-six pounds per square inch above the atmosphere. The relation of other temperatures and pressures are shown in Table I.

TABLE I.

RELATION OF TEMPERATURE AND PRESSURE OF SATURATED VAPOUR OF SULPHUR DIOXIDE (SULPHUROUS ACID), ACCORDING TO REGNAULT.

Temperature Fahr.	Pressure in Pounds Per Square Inch Above Zero, Sulphur Dioxide Vapour.
32°	21 lbs.
50°	33 "
68°	48 "
86°	67 "
104°	91 "
122°	120 "
140°	156 "
158°	201 "
176°	255 "

Fig. 1 is a skeleton drawing, showing the leading features of the system. The primary engine A is worked by steam in the ordinary way. The exhaust steam passes into a surface condenser B, in which the circulating medium is sulphur dioxide, which is thereby evaporated. The SO_2 vapour at the pressure due to the temperature of the condenser B, passes into the secondary cylinder C, where it develops power, expanding down to near the temperature corresponding to the circulating water in the condenser D, into which the vapour is exhausted. The condensed vapour passes to the pump E, which carries it back to the evaporator, or condenser, B, where it is ready to repeat the cycle. Neglecting the losses through possible leakage, the SO_2 vapour is used over and over again, and requires no replenishing.

The steam engine used with this apparatus is a triple-expansion, steam-jacketed machine, of which the dimensions are as follows:—

Diameter H. P. cylinder	10.5"
" intermediate cylinder	16 15/16"
" L. P. cylinder	26 9/16"
Stroke	19 11/16"

The cylinder using the sulphurous acid vapour is 10 1-16 inches in diameter and of 19 11-16 inches stroke. The load on the engine consisted of an electric generator used for lighting The data and results of thirteen different tests are given in the pamphlet, all of which reveal a gain in power due to the use of the SO_2 engine, varying from 30 to 40 per cent., according to the degree of vacuum in the condenser or evaporator. The results of three of these tests are given in Table II., on the next page, the first being one of the earliest tests made on the engine soon after it was installed, using highly superheated steam. The second was a similar test made three months later, and during the interval which transpired the valves of the first two cylinders had become worn by the action of superheated steam and were then no longer tight. The third test was made with dry, saturated steam, the superheater being out of service.

Copies of sample indicator diagrams from all four cylinders are reproduced from those given in the pamphlet for Test B. As appears in the table, the first test (Test A) showed a consumption of 11.02 pounds of steam per I. H. P. per hour of the steam engine, and 8.25 pounds per I. H. P. per hour

of the combined steam and SO_2 cylinders.

The sample diagrams for Test *B* account for about 11 pounds of steam per I. H. P. per hour in the high-pressure cylinder (assuming the steam to be saturated), and 10 pounds in the low-pressure cylinder. These diagrams, however, refer to a heavier load than that of Test *A*, and, therefore, cannot be applied accurately to that test; but making due allowance for this difference, and also allowing something for the superheated condition of the steam which it probably possessed in the high-pressure cylinder, it seems possible that with perfectly tight valves and pistons the engine might have operated with as low as 10 pounds consumption of steam per I. H. P. per hour. It is hardly possible, therefore, to attribute the low consumption of 8.25 pounds per I. H. P. per hour which was obtained on the combined system to any other fact than the inherent advantage of the binary principle.

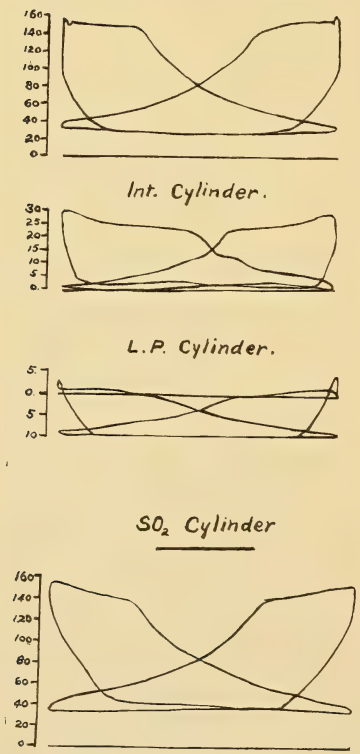


FIG. 2.—THE SCALES REPRESENT POUNDS PER SQUARE INCH

TABLE II.

DATA AND RESULTS OF TESTS ON THE COMBINED STEAM AND WASTE HEAT ENGINE AT THE TECHNICAL HIGH SCHOOL, BERLIN, GERMANY.

Letter or Number Designating Test	*A*	*B*	*C*
Kind of Steam	Superheated		Saturated
Speed, Rev. Per Min.	136.3	148.0	149.0
Steam Engine.			
1. Temperature of boiler steam, degrees Fahr.	588.0	590.0	373.0
2. Steam pressure above atmosphere, lbs.	156.0	136.0	156.0
3. Degrees of superheating	215 0	217.0	0.0
4. Vacuum in condenser, inches	24 0	20 0	20.0
5. Indicated H. P. developed by steam engine, I. H. P.	127.1	164.4	158.7
6. Steam consumed per I. H. P. per hour, lbs.	11.02	12.92	16.08
Waste Heat Engine.			
7. Temperature of SO_2 vapor supplied to cylinder, degrees Fahr.	133.7	156.0	153.5
8. Temperature of SO_2 liquid from condenser, degrees Fahr.	66.0	68.0	70.0
9. Temperature of circulating water inlet, degrees Fahr.	50.0	51.0	51.0
10. Pressure SO_2 in vaporiser, lbs.	128.0	186.0	180.0
11. Pressure SO_2 in condenser, lbs.	33.0	36.0	38.0
12. Indicated H. P. SO_2 cylinder, I. H. P.	43.5	62.2	67.0
Combined Engine.			
13. Total I. H. P. steam engine and waste heat engine, I. H. P.	170.6	226.6	225.7
14. Steam per I. H. P. per hour, lbs.	8.25	9.39	11.35
15. Gain in economy by SO_2 engine, per cent.	25.0	27.0	29.0

Analysing the results with reference to the effect of the SO_2 cylinder, the striking fact appears that under all conditions of the steam engine, whether working with superheated steam or with ordinary saturated steam, whether worked with high or low vacuum, whether in good condition as regards tightness of valves, as represented by Test *A*, or in bad condition, as revealed by Test *B*, the general effect is the same, namely, that the use of the secondary engine, worked on the binary

principle, secured a substantial increase in the amount of power developed, the effect being so great that a higher economy is finally obtained than is possible with any arrangement of steam engine in its unaided state.

The performance of this engine, as compared with the best results heretoore obtained, can best be shown by reducing the results to the basis of heat units consumed per I. H. P. per hour Assuming a temperature of 142 degrees for that of the feed-water entering the boiler, which corresponds to a vacuum of 24 inches on Test *A*, each pound of steam required for its vaporisation and superheating 1188 B. T. U. The consumption of heat units per I. H. P. per hour on Test *A* was, therefore, $1188 \times 8.25 = 9801$ B. T. U., or 163.3 B. T. U. per I. H. P. per minute. Assuming that the boiler is of such efficient type as to utilise 80 per cent. of the heat value of the coal, and assuming that the best class of coal is burned in the boiler, giving, say, 15,000 B. T. U. per pound weight, the economy in coal consumption is represented by $9801 \div 12{,}000 = 0.817$ pounds of coal per I. H. P. per hour.

In a paper by Dr. R. H. Thurston at a meeting in 1899 of the American Society of Mechanical Engineers on "The Steam Engine at the End of the Nineteenth Century," the statement was made that the limit of progress in the development of the steam engine attained to date is represented by an economy of 11,160 B. T. U. per I. H. P. per hour, or 186 B. T. U. per I. H. P. per minute. The status of the engine described by Prof. Josse, using 9801 B. T. U. per I. H. P. per hour, requires no comment.

Unless the further development of the system should reveal insurmountable difficulties in the way of successfully handling sulphurous acid for this purpose, these experiments open up a new field in the development of the steam engine which will make it an easy matter to obtain an hourly horse-power with a consumption of considerably less than one pound of coal.

HEALTHFULNESS OF GAS LIGHTING

By Edward A. Harman, M. Inst. C. E.

IN one of the Yorkshire papers recently there appeared an extract from a London paper's correspondent as follows:—

"If gas dries the air, so much the better; the proper plan is to burn it very low all night. In cold weather it should never be put out; it should be raised or lowered according to the outside temperature."

The advantage of having the temperature inside a room greater than outside is apparent for a variety of reasons. Justification for a gas light has not always been so clearly and intelligently recognised as in the foregoing paragraph. In accordance with well-known laws it is imperative that heated air ascends.

In rooms where it is the practice to allow a window to remain open a little at the top this heated and foul air escapes, fresh air entering to supply its place. A common outcry and complaint against gas is that sometimes a slight sulphurous odour can be detected, though the quantity is very small. Considering the extensive adoption of the medical sulphur treatments all over the world in cases of consumption and other lung affections, one cannot conceive that a small quantity of sulphur is injurious; indeed, on the contrary, it is strange if it is not even beneficial to health.

The writer remembers travelling in a train with a gentleman of extended experience, and when about to go through

a tunnel he proceeded to close the window, but his experienced friend objected, remarking that he always preferred to travel through a tunnel with the windows open so as to get the full benefit derivable from the sulphur. He attributed his strong lungs and the splendid condition of his chest to this habit, which he insisted was a most beneficial one, particularly in his case, where he had heavy duty as a vocalist. He also gave it as his opinion that there would be fewer cases of weak lungs and even fevers if more sulphur were freely inhaled.

Another case much upon the same lines is within the writer's recollection. A medical gentleman travelling between Yorkshire and London was astounded to see a mother holding her baby at the open carriage window when passing through a tunnel, and in his amazement inquired the reason for this apparently insane proceeding. Her reply was that the child suffered from croup and the physician had recommended "tunnel air" for it.

It is a common practice in districts where asthma and bronchitis are prevalent for people to purchase at the gas works a small quantity of tar, which is put into a gallipot jar or other vessel and placed under the bed, the experience being that the gases emanating therefrom have a soothing effect upon the lungs. It is well known that gas works are regarded as first-class health resorts for children suffering from whooping cough. The writer remembers many children troubled with this plague being brought to gas works and being carried or walked about for an hour or more around the opened purifier boxes, tar syphons, etc. The more sulphurous and ammoniacal the odours were the greater the relief the children obtained.

One would think from the popular objections that the least trace of sulphur in the gas, instead of being beneficial to health, as the writer claims, was harmful. It is a fact that the action of sulphur upon disease germs is fatal to them, as demonstrated when sulphur is used as a disinfectant.

Sometimes in entering a room which is electrically lighted it is found that the air is heavily charged with carbonic acid, of which the occupants are oblivious, the complaints of headaches and depression being attributed to any other cause than the right one. The same conditions prevail frequently in churches, chapels and large public buildings lighted by electricity, where the audience are sitting in an atmosphere surcharged with carbonic acid, due to the fact that the electric lamps do not emit sufficient heat to promote ventilation.

Other more discreet and sagacious managers have tried to provide against this lack of ventilation by placing gas burners in the roof and thereby creating an upward draught independent of the lighting arrangements.

The use of gas has been objected to on the ground that it sometimes contains traces of ammonia which is foolishly considered injurious to health. Ammonia does not support combustion, and, therefore, if present in the gas, passes off direct into the room in which the gas is burnt; but so far from its presence being detrimental to health, it has been established beyond all dispute that a small quantity of it is actually beneficial.

Considering how largely in demand sulphur is at retail and wholesale chemists either in tabloid, soap, powder or other form, and that ammonia salts are regarded by some as essential to their very existence, while ammonia for baths is all the rage nowadays, how passing strange it is that complaints should be made that the consumption of gas is detrimental to health, if not even poisonous, when undoubtedly the very thing objected to is a positive physical stimulant and health preservative.

EDUCATION FOR THE MACHINE TRADES

By S. M. Vauclain, Superintendent of the Baldwin Locomotive Works

The remarks here reproduced in part were made in the course of a recent discussion of the needs of industrial education in America before the Engineers' Club of Philadelphia.

THERE is nothing so conducive to success in any manufacturing establishment as its personnel, from the president down to the watchman at the door. A certain *esprit de corps* is necessary to insure success, and that, in turn, is dependent upon the education of the entirety. It is not my intention, however, to treat of that which is necessary for the many varied classes of employees, but to devote what little time may be at my disposal to the consideration of the education necessary for the apprentice. What an ocean of thought is necessary for his benefit! I have been asked,—" Are the present or existing educational conditions satisfactory?" To which I can reply both " Yes " and " No." They are satisfactory in that they provide those who are permitted by their parents to attend our public schools with a rudimentary education sufficient to build upon for the future; also in that they cause our high schools, both public and private, to daily charge the minds of young men with an excellent groundwork, the application of which to any of the various trades in the mechanic arts must insure success.

Also and more particularly are our colleges, several in number, engaged in the education of young men destined to fill many of the more important places in our manufacturing enterprises, provided their future may not be dwarfed by an overestimate of their worth.

And now as to the negative, and listen to me closely, in order that you may derive the full import of my perhaps not too clear explanation.

The education of our youth in the mechanic arts thirty years ago was conducted in a sort of " raised-by-hand " manner. The indentured apprentice was just ceasing to be, and the unindentured youth was being substituted in his place. The ambition of boys worthy of advancement was dwarfed by the favouritism practiced by superiors. The greed of gain and the struggle for distinction caused owners and their foremen to introduce labour skilled in but one thing,—to work the youth of the land in such a manner, until, arriving at that age when red neckties and young ladies became attractive, a demand for better wages would be met by a rebuff or dismissal. Why have we our system of education as practiced by the public schools? Why do the high schools of our land exist? And lastly, why should we send our sons to colleges and other institutions of learning if they must buffet a condition so damnable to the youth of the land?

In my opinion, when our youth have left their schools and stand ready to enter upon their life's work, there should be a well-defined system pursued by the owners of all industries; not only should we revive the old system of indenture, but we should improve it to meet the various grades of boys seeking places. The grammar school boy must receive even more attention than his more scholared fellows; his term of service will naturally be longer, but that which he may have lost at school will be more than made up by his better knowledge of shop practice and longer contact with men,—men whom he must either mingle with or command.

Therefore, a series of indentures which shall suit the boys or young men of these three grades must be prepared,

and must insure a regular and uniform progress in the art or mysteries of the desired trade, be it that of machinist, blacksmith, boilermaker, or other, and even though it may in some cases prove a loss to the individual, the whole will be benefited.

It may be claimed on the part of those intrusted with the education of our youth, prior to their engaging in any occupation intended to provide a livelihood for them and those to be dependent upon them in the future, that the so-called manual training schools of the country are sufficient and well adapted to educating and training a class of skilled workmen,—skilled not only in the manipulation of machine tools, but thoroughly trained in the art of expressing their ideas upon paper in the shape of drawings, so that those thoughts can be transmitted to others clearly enough to enable them to follow. It is in this manner only that the direction of thousands can be accomplished by a few.

But while I do not wish to detract in any way from the good influence which may be asserted by the various institutions of mechanical handiwork, or so-called mechanical training schools, it is a fact that these schools are lamentably behind the times in all that appertains to the various trades as practiced in America to-day. The professors engaged in imparting knowledge to the various pupils in their charge are endeavouring to the best of their ability to discharge the obligations resting upon them. They are handicapped, however, by the fact that to be a successful teacher in this branch of education it is necessary to be in constant contact with the practical work of the workshops of the country, and to have at their command all the improvements that are made in the way of labour-saving appliances and improved methods of operation, so that, when graduated, their students may at least be abreast of the times and ready to proceed with their work in some one of the many great workshops.

The financial difficulty, however, interferes in almost every case, and in many of the workshops connected with educational institutions the machinery and appliances provided are lamentably deficient. It is my opinion that the money now spent by the various trade schools, mechanical training schools, and others of this kind, would be put to better use if devoted to a thorough teaching of algebra, geometry, mensuration, mechanical drawing, and, if possible, some higher mathematics, sweetened and made palatable by an elementary knowledge of the chemistry of metals and their physical strength. If the workshops which are already thoroughly equipped with valuable and efficient teachers, were organised as manual training schools,—manual training schools that would pay to each student sufficient money to at least furnish him with the "bread of life," in place of, as in our present system, consuming his time without compensation and at a considerable outside expense; manual training schools that would carry along the successful student in such a manner as to eventually make him not only a success from the mechanical training standpoint, but a mechanic of the highest order,—such schools would turn out young men not only trained from a thoroughly mechanical point of view, but so thoroughly trained on the commercial side of the profession as to make them a financial as well as a mechanical acquisition to our country.

No one but those who employ labour or operate large machine shops are aware of the deplorable failures of those who enter their works from the mechanical training schools. Give me the boy who has a thorough groundwork, a knowledge of the common branches taught in our grammar schools, a knowledge of the higher branches taught in the High School of Philadelphia and others of its kind, or a graduate of such colleges as Sibley, Stevens, and the University of Pennsylvania, and I will be responsible for the mechanical education of these young men and for their adaptation to all positions connected with the various trades to be found in the industry with which I am connected.

Why is it that we cannot secure apprentices to the trades of blacksmith,

boilermaker, or moulder with the same ease that we do to that of machinist? Can it be that our education, so called, gives the youth of our land a horror of such work, or is it not due to the fact that hardly an establishment in the whole United States offers any encouragement whatever to young men in these branches? They naturally shrink from the grime and the excessive manual labour, but these trades to-day, while bare of ambitious material for their perpetuation, offer the most desirable future for our youth, and in them the financial as well as the professional reward seems the greatest.

The Baldwin Locomotive Works is endeavouring to start this great system of education. Among 10,500 toiling mechanics you will find more than a thousand young and ambitious men, variedly educated, toiling unceasingly for recognition and advancement.

They have before them other youths who have successfully ridden out the stormy years of their apprenticeship and journey work, and are now holding positions of great responsibility. Why has the Baldwin Locomotive Works grown so rapidly within the last decade,—almost fourfold in size? Three thousand men were then considered many, but the enterprise of youth and a system of persistent shop education as a continuation of that received at school have swelled the numbers, burst out the walls, driven out trade into every quarter of the earth, and to-day you will find an army of men whose loyalty to their place of employment, energy of action, and their susceptivity to direction are the admiration of all who visit those works.

It has been said that God made all men equal. In many ways this may be true, but not as to their capacity. We have daily born in the world those destined to command and those who must labour. It is true that many are drawn into the mire of error and despondence who otherwise would be a credit to the country, and it is to avoid this that we must all enter the arena of educators, and by daily contact sort out the youth of the nation, advise and direct, and so place and encourage them that they may all be successful comparatively and add to the prosperity of the nation. The commander is seldom an investigator, the delineator seldom an inventor, the mechanical "crank," with whom you are all no doubt acquainted, fulfils his mission, an ever-present warning to young men suffering from their first megacephalous condition. Therefore, it remains for us to get to work faithfully and diligently, and, at no little expense, to discharge our obligations and insure a continuance of our present prosperity to those who will follow hereafter.

In conclusion, let me tell you we must bear in mind that the greatest secret of success in our varied industries is to avoid family succession, excepting where it may have been successfully toiled for and earned shoulder to shoulder with other strugglers for the same end. When Mr. George Burnham, senior member of Burnham, Williams & Co., owning and operating the Baldwin Locomotive Works, was asked to explain the success which attended his establishment, he replied,—"There are no hereditary rights connected with the Baldwin Locomotive Works."

Let this then be the watchword of every manufacturer:—It is far better to give your business to a competent stranger, educated under your own roof, than to entrust it to an irresponsible and disinterested progeny, not only from a pecuniary point of view, but for the betterment of humanity and the preservation of the industries of the country.

Current Topics

THE promises of economy gains from burning pulverised coal have for years led to persistently recurring experiments, and each new venture in the field has been heralded with claims of final success. After all, however, experience in every instance seems to have ultimately demonstrated that it is difficult to obtain combustion of such fuel with as small an amount of air per pound of fuel as can be obtained in the best practice with coal fired on an ordinary grate, and this has always tended to make the economy lower than with the usual method. Besides this the power required to operate the coal pulveriser and feeder has counted against the efficiency of the plant as a whole, and there is generally some difficulty from the collection of ashes and unconsumed particles of coal in the back connections of the boilers. Judging from all available data, these drawbacks still remain to be overcome.

ECHOES of Marconi's alleged reception of wireless signals across the Atlantic Ocean are still reverberating from shore to shore of the two continents, and arguments without number for and against the probability of the actual reception of such signals have been offered. The consensus of opinion, however, is that expressed in these columns at the time, namely, that if Marconi is honest, which no one questions, he received the signals as he states. A fall in the value of cable stock consequent upon the announcement of this accomplishment took place with the promptness predicted in the February number of this magazine, a drop of from 25 per cent. to 80 per cent. having occurred in some of the principal cable shares, due to what amounted to almost a panic among the shareholders. The needlessness of this is, of course, apparent to anyone at all conversant with the difficulties that are still to be surmounted before even ordinary short-distance wireless telegraphy can be brought to a fairly reliable standard; but the general public is not conversant with these difficulties, and, with the object of stiffening the backbone of the nervous shareholders, the presidents of the Atlantic and other cable companies have secured the opinions of the leading electricians of Great Britain to show the unlikelihood of any serious effect of wireless telegraphy on their business. It has even been intimated that the prospect of this competitor in the field may incite the cable

managers and engineers to better things. For instance, that exceedingly sensitive instrument, the coherer, or a modification of it, may be found applicable to cable working, and, if so, a considerable increase in the speed of cable signaling may follow, since it is known that the weaker the current necessary to operate the receiving instrument the higher may be the working speed of the cable. Thus, when the first Atlantic cable was laid, the ordinary Morse telegraph relays were employed, and with them the rate of working was only two or three words per minute; but with the vastly more sensitive instruments subsequently employed the speed was increased to twenty-three words per minute. As the coherer is many times more sensitive than the present cable receiving instrument, it is possible that this later advance in the telegraphic art may ultimately prove a boon to submarine cable working.

The one thing upon which Marconi has insisted more than another is that it will be impossible to receive or interrupt a message transmitted through one of his tuned transmitters by untuned transmitting and receiving apparatus, and as this point is disputed quite as vigorously as it is asserted, Marconi, in an interview, has offered to pay £100 to anyone who will interrupt or read one of his tuned wireless messages. Inasmuch as it costs several hundred pounds to properly equip a wireless telegraph station, this offer is presumably safe. An easier plan would seemingly be for Marconi to invite a few representative scientists and practical men to witness the actual operation of some tuned circuits, and at the same time afford them an opportunity to endeavour to interrupt the transmission of messages by his tuned apparatus. In the same interview Marconi announces that he intends to commence operations by cutting the transatlantic cable rates one-half, and would afterwards reduce the rates for short-distance land service. This savours somewhat of stock "booming" or stock bearing, and it is perhaps to be regretted that Marconi, in this instance, appears to have departed from his former custom of withholding information concerning his plans until they have been worked out practically. On top of the "boom" in wireless telegraph stock comes a report from Honolulu to the effect that the Marconi system between several of the islands of the Sandwich group has failed as a commercial undertaking. The distance covered by the system was about 150 miles, with relay stations at intervals of 20 to 30 miles. The rate for messages was two dollars for ten words and twenty cents for each additional word. Complaint was made that many messages went astray, but apparently the chief difficulty was a lack of funds to pay running expenses. It would seem that, as a matter of business policy, the parent company should have taken steps to keep this system alive, inasmuch as it was the first attempt at a commercial application of wireless telegraphy on a fairly large scale.

It appears to be a popular impression that, given the necessary apparatus for wireless telegraphy, anyone can operate it. In the article on this subject in the January number of this magazine it was pointedly noted that it would be found necessary to employ trained experts to properly operate the system, and that this fact would make it impracticable to introduce the system at random on all kinds of sailing craft. This fact has been recognised by the Marconi interests, and a training school to turn out experts in the practical operation of wireless telegraphy has been established at Frinton, on the English coast.

In an argument before the United States Committee on Labour against the pending so-called eight-hour labour bill, Mr. Archibald Johnston, general superintendent of the Bethlehem Steel Company, recently detailed, in a very interesting manner, why a period of more than eight hours of continuous labour is sometimes vitally important to the suc-

cessful prosecution of certain kinds of work. While he confined himself chiefly to the practical difficulties in casting and forging steel, he mentioned also another class of work,—machinists' work in gun manufacture,—which would be greatly hampered by the bill in question. The Bethlehem Steel Company, for example, he explained, manufacture guns of various classes, some of which they deliver completed, while others they carry along to a certain stage and then turn them over to the United States Government to be finished and assembled. This work requires great accuracy in the measurements, and it is a well-known fact that the measurements of no two men agree absolutely. On this government work the inspectors insist that the makers shall work to thousandths of an inch, although on most commercial work if they get within a hundredth of an inch they are close enough. Now the measurements of different men disagree so much that what would be 15 inches to one man, another might call 15.003, while still another, measuring the same piece with the same instrument, would call the dimension 15 inches minus 0.003, each one being certain that his measurement was correct. This is accounted for in large part by the difference in delicacy of touch in different people.

It may seem ridiculous, but it is nevertheless a fact that the temperature of the hand can so affect a micrometer caliper as to make a difference of 0.005 or 0.006 in a measurement of the same piece by different people. We are well aware of the difference in temperature of the hands of people with whom we come in contact. As a result of this, in order to standardise measurements, the Bethlehem Steel Company are compelled to maintain the temperature of their machine shop where this particular work is carried on at 76 degrees, and the inspection is so rigid that the government inspectors will not measure parts of guns for assemblage when the temperature of the shop varies more than eight degrees above or below this point. For this same reason the person who starts a cut for a shrinkage surface must finish it regardless of the time consumed in so doing. It is well understood, of course, that all cuts cannot be completed within eight hours, and it is equally well understood that the company cannot afford in these times of severe competition to allow their machines to lie idle in order that eight-hour periods may be attained for accomplishing each particular operation, even though eight hours would be sufficient to finish the operation. An interrupted cut can easily be detected by delicate measuring instruments on gun tubes or hoops, or other pieces of work where accuracy of dimensions is the chief object sought. This is owing to the fact that the pieces cool off and the tool used in doing the cutting also cools off, and when the tool is started again the point at which the cut was interrupted can easily be determined. It is, therefore, necessary that a finishing cut should be completed without interruption; hence for these guns the very best of steel is used and the final cut is made as light as possible in order that the tool may last until the end of the cut.

The irrepressible conflict between gas and electric lighting interests finds vent occasionally in unexpected directions. At one time it is the gas advocate proclaiming the dangerous nature of electric light wires as a frequent cause of all fires that are mysterious. At other times it is the advocate of electricity raising a warning voice against the earth-filtered, odourless illuminating gas, which, escaping from the leaky mains, enters our abodes undetected, and doubtless occasions all fires of which the source is not otherwise explainable. The truth, however, is that the managers and directors of the various electric light and power companies and gas companies are much more alert to eliminating all kinds of suppressable leakage and other losses than the general public imagines. In both industries there is a large annual loss, more or less unaccounted for. In the gas industry a small percentage of this

loss can fairly be attributed to actual leakage from the mains, and no expense is spared to minimise this loss by prompt and constant repairs and renewals. A larger proportion of the gas sent out, but not accounted for, may be properly attributed to defective meters, and, in the case of street lighting, to a greater consumption of gas in the lamps than is allowed for on the books, and so forth. The total amount of unaccounted-for gas, that is, the difference between the amount recorded by the station gas meters and that recorded by the consumers' meters, varies in different places, but probably it does not exceed an average of 10 per cent. of the amount of gas generated, of which, perhaps, less than 2 per cent. may be properly charged to leakage at the mains. This rate of leakage in the larger cities amounts to about 500 cubic feet of gas per day.

THE unaccounted-for gas loss is at least equalled by accounted and unaccounted-for losses in the supply of electricity from central stations, where it is known to range from 10 to 60 per cent. of the output. Comparatively little of this loss is, however, due to actual leakage of electricity from the conductors, especially where the wires are underground, since a serious escape of current very quickly makes itself felt in the operation of the system, and thus leads to its prompt detection. The major losses are in the conductors themselves, in the core losses of the transformers, where transformers are used, and in the recording meters on the consumers' premises. Hence, strictly speaking, these losses are not unaccounted for, since the line and core losses are easily calculated. Statistics indicate that in the case of gas and electricity supply the percentage of slow-running meters is largely in excess of the fast-running meters. The loss from this source may perhaps amount to from 4 to 6 per cent. in the case of electric meters. It is, unfortunately, a fact that in numerous instances central stations of electricity supply are not equipped with recording wattmeters, and, consequently, have no check upon their losses.

SOMEWHAT apropos of this subject it may be noted that the uses of electric light are not charged for light, but for electrical energy when recording wattmeters are used, or, in other words, for kilowatt-hours. It is, therefore, very much to the interest of the user to have lamps of high efficiency, but not perhaps equally so to the central station manager, who, if it were possible, at one stroke, to provide a lamp having double its present efficiency, would find half his occupation gone, and for this reason some timid station managers look askance and with misgivings upon any improved lamp efficiency. Such misgivings are unnecessary, since, almost without exception, experience has shown that advances of this nature lead to increased use of the commodity, and thus things equalise themselves. The Welsbach or Aner light was an instance of this, and the gas people, to their credit. be it said, were quick to avail themselves of it.

SAWDUST in cake form appears to have been used as fuel in Germany with rather promising results. United States Consul A. L. Frankenthal, writing a short time ago from Berne, Switzerland, says that the sawdust cakes are octagon-shaped, 6½ inches long, 3½ inches wide and three-quarters of an inch thick, weighing about half a pound each. In the district surrounding the factory where these cakes were made the schools were heated by them, the combustion leaving very little ash and proceeding without a large flame. No binding ingredient is said to be used, the sawdust being simply dried and pressed into the desired briquette shape, and owing, thus, to the absence of tarry or oily substances, there is no smoke in burning. The weight of such a briquette indicates the heavy pressure under which it takes its shape, and the edges look

like polished oak; in fact, it is heavier than a piece of hardwood of the same size. The demand created by the popularity of the fuel exceeded the supply of sawdust obtainable in the vicinity of the factory, and shiploads were, therefore, procured from Sweden and carloads from distant manufactories. Sawdust, which previously could be had for the asking, demanded a market price as soon as it became known that a certain factory could make use of it. Even then it was profitable to manufacture the briquettes; but, unfortunately, the factory was destroyed by fire and operations came to a standstill. Making sawdust briquettes of this kind would, therefore, seem to be worth inquiring into further.

It would, at first sight, seem that there would be very little inducement to thefts of copper wire from poles, considering the likelihood of detection, not to speak of the danger to life connected with the operation; but, as a matter of fact, no country is exempt from depredations of this nature. In the case of one high-tension electric lighting system the service has been interrupted at different hours of the night by the removal of hundreds of feet of wire from the poles by expert pilferers. Similar reports have at different times come from many places, and quite recently the telephone system of Sweden has been seriously crippled by the unwarranted removal of large sections of copper wires from the lines, the iron wires of the same system being left untouched. Nor is this a new industry, for it has been going on for years. One of the chief obstacles, it appears, in the way of preventing this form of larceny is the difficulty on the part of the companies in proving property unless when the pilferers are caught in the act, for there are no identifying marks on copper wire, especially after it has been melted. It is interesting to note, in connection with this, that one Moses Wright, as long ago as 1852, was found guilty of merely cutting the telegraph wires in Marlboro district, S. C., and for this offence was sentenced "to receive thirty-nine lashes on the bare back, publicly, to leave the district in ten days, and each and every time he is caught in the district to receive thirty-nine lashes, without farther trial."

In expressing its views regarding new vessels for the Navy the United States Board of Naval Construction, in a recently submitted report, places itself on record against sheathing the bottoms of ships, favours Kropp armour, and advocates the instalment of guns not heavier than 12-inch calibre. In the opinion of the board the advantages resulting from sheathing are more than offset by the disadvantages. It admits that sheathing and coppering are a partial protection against fouling, but believes that under ordinary conditions the bottoms of vessels can be kept clean by the use of anti-corrosive and anti-fouling paints. Concerning armour, the board says that both battleships and armoured cruisers should carry as much armoured protection as is practicable without detriment to their other important features. Eleven inches is the maximum thickness of the armour of the best quality considered necessary or desirable for battleships, and for armoured cruisers 6 inches for the heavy part of the main belt, 8 inches for the turrets and barbettes, and 9 inches for turret port plates. The elliptical balanced turret, with inclined port plates, is considered the best.

Twelve-inch guns are the heaviest considered necessary for battleships, with a combination of 7-inch and 8-inch rapid-fire rifles for the intermediate battery. Four 10-inch guns and sixteen 6-inch rapid-fire guns have been selected for the armoured cruisers. This, says the board, gives these vessels phenomenal powers of offence, equalled by none in the world, and fits them to take their place in the line of battle, if necessary. Torpedo tubes and torpedoes on board armourclads are not regarded as necessary by the board. The board justifies

its reduction of the speed of the new battleships from nineteen to eighteen knots by the statement that very high speed can be obtained only by a great sacrifice of weight and space without a corresponding gain in efficiency.

THE plans for the new armoured cruisers contemplate vessels 502 feet long on the load water-line, having a breadth of 78 feet 8½ inches, a trial displacement of about 14,500 tons, a maximum displacement at full load of about 15,959 tons, a maximum draught of about 27 feet, indicated horse-power of 25,000, and trial speed of not less than 22 knots. The armament will consist of four 10-inch rifles, sixteen 6-inch, twenty-two 3-inch, twelve 3-pounders and fourteen smaller guns. The armoured water-line belt will be 7 feet 6 inches wide, having a maximum thickness of 6 inches over the vitals and tapering to 3 inches at the ends. The barbettes for the 10-inch turrets taper from 7 inches to 4 inches in thickness; the turrets of the 10-inch guns are 8 inches thick, with 9-inch port plates. The conning tower and its shield are 9 inches thick. Each vessel is designed to carry 854 officers and men.

THE battleships are to be 450 feet long, 76 feet 8 inches wide, of 16,000 tons trial displacement, 17,604 tons maximum displacement, 26 feet 9 inches maximum draught, will carry 2200 tons of coal, have an indicated horse-power of 16,500 tons and a trial speed of not less than 18 knots. The battery will consist of four 12-inch guns, eight 8-inch guns, twelve 7-inch guns, twenty 3-inch, twelve 3-pounders and eighteen smaller guns. The armour belt is 3 feet 3 inches wide and tapers from 11 inches amidships to 4 inches at the stem and the stern. The 12-inch barbettes are 10 inches thick, and the armour on the 12-inch turrets is 9 inches thick with 11-inch port plates. Quarters are provided for officers and crew numbering 797.

DELIVERING fuel oil to houses and factories just as gas and water are delivered now, through pipe systems, is one of the schemes which is said to have been prompted by the latest oil discoveries in the United States. According to report, a purchase offer has been made for one of the city waterworks with the view of closing it for water purposes and re-opening it for the oil business. The present reservoir, which will hold about 20,000,000 gallons, is to be converted into an oil tank, and the mains are to be used for carrying the oil at a minimum cost to consumers. It would only be necessary to turn on the water cock to get as much oil as a consumer needed, and a meter would keep account of the amount supplied, thus affording, it is thought, the most perfect system of fuel oil distribution in the world. The oil would be pumped from one of the oil fields to the reservoir, and from this, by natural pressure, without further pumping, it would be distributed to all the points of consumption in the city. With the reported money interests backing the project, this would seem to be entitled to rather more than passing consideration.

SEVERAL striking instances have been given by Sir John Wolfe Barry, one of the members of the recently appointed British standardisation committee, of the way in which money is lost or wasted by British engineering establishments through the lack of standards in iron and steel sections and the ordering, by engineers, of odd shapes, not in stock, for which there are no rolls, and for which, because of the small size of the order presumably, it would not be expedient to specially cut rolls. In one of the cases, for the sake of an Indian order, a firm had to supply channels 10 × 2¼ inches, and the only way in which they could, under the circumstances, be obtained was to take 10 × 3-inch channels and plane them down. In another case the same firm had to plane a bar of 3½-inch square section into an angle-bar of 3½ × 2 × ¾ inch. And this, it should be stated, was not

to replace old work, where possibly some good excuse might have been found for it, but for a new order and a new design.

THERE is a common belief that electric incandescent lamps give out very little heat, and that, therefore, fire danger from them is practically non-existent. Hence it is that such lamps are frequently found disposed with much unconscious carelessness in the neighbourhood of combustible materials, in shop windows, for example, for decorative effect, and the wonder is that fire losses from such use of the lamps are not more widespread. Many experiments have been made and recorded to show how real these lamp fire risks are, and reference to some of them will well bear repetition as possibly useful in emphasising the need of greater caution in securing illuminating effects. In one case where a lighted lamp rested against a vertically placed white pine board a spot, about an inch in diameter, and of a light-brown colour, appeared after about four hours. In the case of a similarly disposed strip of well-seasoned, varnished oak, the varnish became blistered in three minutes and blackened in about fifteen. The wood had the appearance of being charred at and near the point of contact with the lamp, but was not ignited. With a lamp encased in two thicknesses of muslin, the latter became scorched in one minute, in three minutes gave off smoke, and at the end of six minutes, when the muslin cover was removed from the lamp and fresh air reached its interior, it burst into flames. Where a lamp was laid on inflammable material, the effect seemed to be more rapid, due, probably, to the pressure exerted by the weight of the lamp. A newspaper was, in this way, carbonised in three minutes and ignited in forty-five. The lamps used were of sixteen candle-power. In one instance, cited recently by the London *Lancet*, it was found that on immersing a 16-candle-power lamp in half a pint of water, the latter boiled within an hour. Again, with a lamp buried in cotton-wool, the wool soon began to scorch and ultimately burst into flame. A lamp in contact with celluloid, fired it in less than five minutes. All these trials indicate, in a fairly conclusive way, what may be expected under certain conditions from a popularly supposed absolutely safe form of light.

INTIMATELY associated with the electric incandescent lamp is the flexible cord connection, and in this we have a probably even more pronounced form of fire risk. In two cases, recorded some time ago, short-circuits developed in cords supporting lamps not turned on, and while the current was almost instantly cut off by the blowing of fuses, the momentary arcs were sufficient to set fire to the cords, which were oily and dirty with lint, being in a cotton mill. In both cases strands of the fine wire had probably broken and pushed their sharp ends through the insulation, causing the trouble, and both occurrences showed that however quickly current may be cut off by properly acting fuses, the heat of the arc produced is sufficient to make the cords burn.

AT a recent meeting of the American Institute of Electrical Engineers the speaker of the evening, in conducting some experiments to demonstrate the effects of opening and short-circuiting high potential circuits, used an adjustable spark gap, or by-path, to measure the potential at the moment of interrupting or short-circuiting the current. This by-path consisted of two metal rods, placed end to end in the circuit. One of the rods was movable, by means of a screw thread, to or from the other rod, and by means of a long cord running in a grooved pulley that was rigidly mounted on the movable rod the spark gap could be increased or decreased at the will of the experimenter and without danger to him. The pitch of the screw thread was such that one turn of the pulley increased or decreased the spark

gap by one thirty-second of an inch. During an experiment, that is, for instance, when the circuit was being repeatedly broken, this gap was varied in the manner stated until sparks just ceased to jump across, when the current was cut off and the turns of the screw were counted. As the calibrations of the spark gap were given on a blackboard, it was easy for the audience to follow the experiments intelligently and interestedly. These calibrations, which give approximately the sparking distances of the respective voltages in ordinary air, will probably be of some general interest, and are as follows:—

Sparking Distance	Volts
1-64 inch	1,800
1-32 "	3,100
2-32 "	5,600
3-32 "	7,700
4-32 inch	9,700
5-32 "	11,500
6-32 "	13,000
8-32 "	16,500
10-32 "	19,700
15-32 "	25,000
20-32 "	29,000

Another speaker at the same meeting pointed out that, unless care were taken, these sparking distances would not be altogether reliable, as the brush discharge preceding the rupture of the air would sometimes give misleading results, especially at the higher voltages. This speaker stated that metal discs, 3 or 4 inches in diameter, placed over the ends of the discharging points would prevent the brush effect and would make the results at least as reliable as can be obtained with the ordinary high-tension voltmeters, up to 30,000 or 35,000 volts.

SAMUEL R. CALLAWAY,

President of the American Locomotive Company

A BIOGRAPHICAL SKETCH

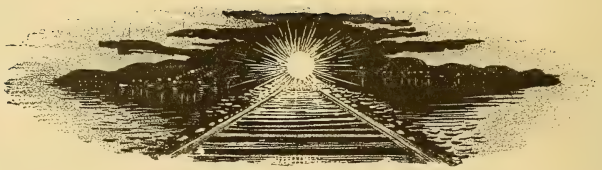
IT is a matter of comment that Mr. Samuel R. Callaway, who last year retired from the presidency of the New York Central Railroad to assume that of the American Locomotive Company, is an unusually conspicuous example of how an humble office boy can rise from obscurity to one of the highest and proudest positions attainable in the transportation business, through his own intelligent efforts and diligence, if in his progress to the goal of his ambition he has the brains, ability and capacity to successfully deal with the varying responsibilities encountered in climbing the ladder of promotion. He is preeminently a self-made man. Broad-mindedness in every sense, kindness of heart and geniality of disposition, with a marked graciousness of manner and freedom from ostentation, are among his distinctive characteristics, and they have enabled him to win and hold the respect and esteem of all who know him. His judgment is conservative and decisive, his grasp and command of all matters relating to executive administration and transportation management prompt and absolute, and his character upright to a degree.

Mr. Callaway was born in 1850, at Toronto, Canada, and when not more than thirteen years old was apprenticed for three years in the Grand Trunk Railway offices, being thereafter employed as junior clerk in the offices of the auditor, chief accountant, and secretary and treasurer. Briefly summarised, his record from that time on was as follows:—From 1869 to 1871, chief clerk to the superintendent of the Great Western Railway; 1871 to 1874, private secretary to the general manager of the same road; 1874 to 1878, superintendent of the Detroit & Milwaukee Railway; 1878 to 1881, general superintendent of the Detroit, Saginaw & Bay City Railroad; 1881 to 1884, general manager of the

Chicago & Grand Trunk Railway and president of the Chicago & Western Indiana Railroad and Belt Line Railway; 1884 to 1887, second vice-president and general manager of the Union Pacific Railway and controlled lines; then successively president and later receiver of the Toledo, St. Louis & Kansas City Railroad Company; president of the New York, Chicago & St. Louis Railroad Company; and president of the Lake Shore & Michigan Southern Railway Company.

As part and parcel of the establishment in 1898 by Mr. W. K. Vanderbilt of a new *régime* for the New York Central Railroad, Mr. Callaway was in that year invited to NewYork, to introduce, as president of the Central, the methods that had proved so effective during his presidency of the Lake Shore road. The measure of his success in the new position was admirably illustrated by the excellent records of the Central road during the succeeding three years.

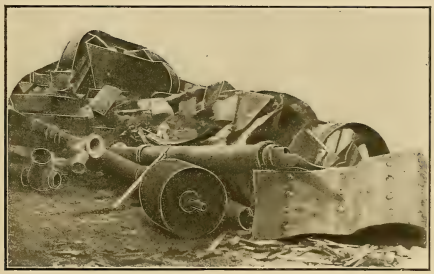
In his acceptance, finally, of the presidency of the American Locomotive Company, Mr. Callaway seized the opportunity which he had desired for some time of getting away from active railroad life and its wearying exactions, though in this latest field of work his energies have been applied as unsparingly as ever.



JUPITER STEEL

WE present a series of illustrations of a plant which possesses especial interest from the fact that it is devoted to a new process of steel-making which promises to exert something of a revolutionary effect in certain branches of the steel industry. Jupiter steel, as the product is called, is an exceptionally high grade of cast steel which is made from wrought-steel scrap, with a liberal mixture of certain other metals during the process of melting. The manufacture is carried on under several patents granted to Andres G. Lundin, and the composition of the steel, the methods of manipulation in the furnace, the special materials and careful work in the moulding, have resulted for the first time in the history of the art in the production of a cast steel which, in tests carried out at the navy yard at Boston, has proved to possess qualities of strength and ductility equal to those of forged steel. These excellent results are obtained, moreover, with but little sacrifice of the high economy which distinguishes ordinary cast steel. Perhaps the best evidence of its remarkable qualities is found in the fact that cold-chisels and hatchets, cast to the finished shape in this steel, will, after being put on the emery-wheel, perform their work and hold their edge with perfect satisfaction; and one of the most striking evidences of what might be called the wrought-steel qualities of this cast-steel product is the fact that at the request of the writer two of these cast chisels were placed end to end and welded with perfectly satisfactory results.

The Lundin patents have been acquired by the United States Steel Company, whose plant is located on the Malden River, West Everett, Mass. The stock yard, which extends for several hundred feet on either side of a spur track from the Boston & Maine Railroad, is the first object of interest at these works. The stock consists of a large variety of mild-steel scrap, among which may be seen boiler-plate clippings, borings from the gunshops, the scrap from sheet-steel works, old crankshafts, and, indeed, any kind of steel that possesses the necessary composition to make up the furnace charge. The melting is carried on in a large furnace house, the steel for the smaller castings being melted down in crucibles and the metal for the larger castings being melted in 25-ton



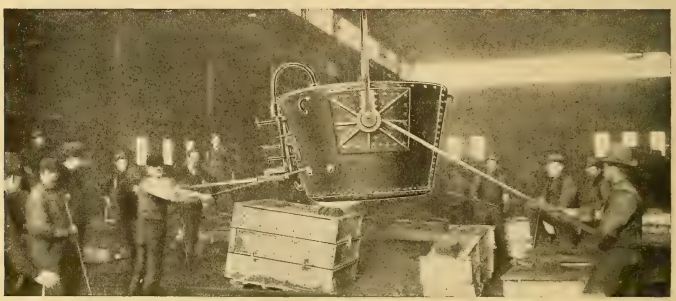
A HEAP OF SCRAP STEEL
The material from which "Jupiter Steel" is made.

Siemens open-hearth furnaces. The preparation of the furnace charge and the introduction of various ingredients during the furnace treatment is carried out in the manner and proportions indicated by the following example, which will serve to show the proportions, but not, of course, the actual amounts which are treated at one time in the furnaces, the latter having, as we have said, a capacity of 25 tons.

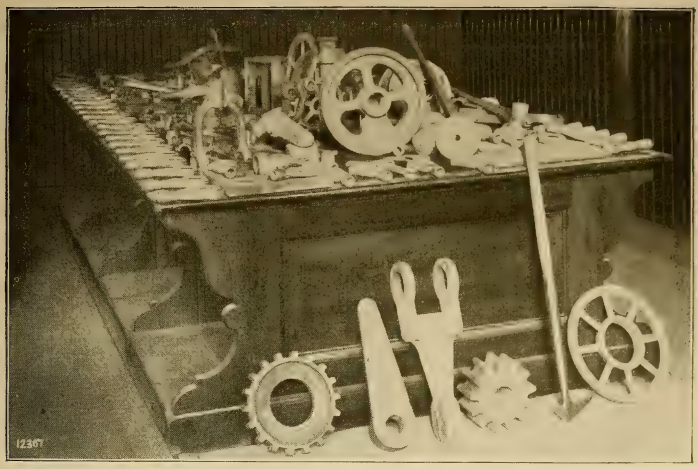
A hundred pounds of steel scrap is placed in a crucible in the furnace and melted to a boiling point of about 4000 deg. F. When the boiling-point has been reached, from one and one-half to two and one half pounds of ferrosilicon, containing 12 per cent. silicon, is introduced into the molten metal. As soon as the ferrosilicon has melted, two to eight ounces of ferromanganese, containing 80 per cent. manganese, is mixed with three pounds or less of aluminium, and this mixture is introduced into the molten metal, where it quickly melts. After the resulting composition is thoroughly melted, it is tapped into ladles, carried to the various flasks and poured into the moulds.

Although the excellence of Jupiter steel castings is, of course, mainly dependent upon the composition and the furnace treatment as above described, particular care is taken in the preparation of the moulds. The moulding sand is composed of a sharp silica sand, crushed rock, fireclay and molasses, which are mixed in the following proportions:—Sixteen shovelfuls of hard silica sand, four of crushed rock, one of fireclay, and one and one half pints of molasses water, the molasses being diluted with water in the proportion of one to one. The molasses is used to give a bonding effect to the sand during the moulding, while the fireclay serves the same purpose during the pouring of the hot metal. After the pattern has been drawn from the mould the latter is carefully dressed up and the finished surfaces are treated with a wash consisting of 99½ per cent. of pure silica, ground fine and mixed with molasses water. The flasks containing the completed moulds are placed in the baking furnaces, and are then ready for the pouring. The two 25-ton furnaces are utilised for the larger castings, and after the heat is ready it is tapped off into ladles which vary in capacity from 10 to 25 tons. These ladles are handled by a pair of overhead, travelling, electric cranes, one of 30 tons, and the other of 20 tons capacity; they travel the full length of the foundry, which at present measures 130 feet in width by 200 feet in length. The building is being extended to a length of 300 feet, and an additional 15-ton crane will be installed. One of our illustrations shows the metal being tapped from the furnace into one of the larger ladles.

When the castings are cooled, they are cleaned by the sand blast, and then



POURING JUPITER STEEL INTO SOME OF THE LARGER MOULDS.



SCRAP STEEL MADE INTO TOOLS AND CASTINGS BY THE "JUPITER STEEL" PROCESS.

all the rough edges are carefully chipped down until the finished casting conforms perfectly to the original pattern furnished by the customer.

In tests recently carried out by the government this steel has shown a tensile strength of 67,300 pounds to the square inch, and an elongation of 25 per cent. in 8 inches, while in the bending tests a 1-inch-square bar of this cast steel was bent cold through an arc of 93.5 deg. without fracture. As a result of these excellent qualities, Jupiter steel is finding a wonderfully wide range of usefulness in the industrial arts. Thus, the shipwork which is being done for the government and private shipbuilding firms includes the rams for the new United States battleships *Rhode Island* and *New Jersey*, each of which castings will weigh 43 tons, and the stern frame, keel and sternpost for the same vessels. Other castings include horseshoes for marine engines, engine thrust bearings, knees, and many small parts ordinarily made of forged steel for the interior construction and fittings of ships, engine beds, engine cranks, crossheads, gear wheels, etc. The castings for the battleships *Rhode Island* and *New Jersey* alone will equal in weight over a million pounds. — *Scientific American*, *October 12, 1901*.

The United States Steel Company has been paying for the past two years quarterly dividends at the rate of 12 per cent. per annum on all its outstanding stock, and this dividend rate will be increased as soon as we can enlarge our plant at Everett, Mass., to meet the needs of a rapidly growing business. To provide for this additional steel building, 100 feet × 130 feet, and a larger working capital to handle the constantly increasing output of Jupiter steel, the board of directors has authorised the sale of a block of treasury shares at par, $5 per share.

Our steel castings are an improvement over the ordinary steel castings because they require no annealing, being strictly pure steel of uniform hardness or softness throughout, and can be welded, tempered, and forged.

Our foreign patents, now being negotiated, show conclusively a source of dividends equal to the entire capitalisation of the company. As a rule, stock in well managed manufacturing companies is generally bought up by those in some way connected with their management, and the outsider has little

chance except at a high premium and a correspondingly low profit. But this is an unusual opportunity for people of limited means to secure an investment already paying a large income, an opportunity such as is usually offered to capitalists only, and a man with a few hundred dollars gets a chance.

In this connection you will note that the *Scientific American* has at last come forward and solicited the information for the above article on Jupiter steel. This is very flattering to us, and we consider it the best endorsement that Jupiter steel has ever received. We shall be pleased to send to those who are interested a full prospectus of the company, together with a record of what has been accomplished in the past two years. Preference will be given to subscriptions in the order of their receipt All accepted subscriptions previous to January 20, 1902, will draw the full regular quarterly dividend of 3 per cent. payable January 28, 1902.

The present plant is at Everett, Mass. a suburb of Boston, where the company owns seventy-four acres of land, having both rail and water facilities. On this land a modern plant, 200 × 130 feet, has been built, provided with electric cranes, furnaces, drying ovens, gas producers, boilers, engines, dynamos, sand blast, crucible plant, finishing machines, office, etc.

A cordial invitation to inspect the plant at Everett is extended to all who are looking for a safe and legitimate investment. Those who cannot do this will have any information desired sent to them promptly upon application to the Boston office, 169 Oliver Street, Boston, Mass.

Make all checks, drafts or money orders payable to the

United States Steel Co.

169 Oliver Street, Boston, Mass.

Manufacturing News

Machine Tools in Germany

A BERLIN correspondent of the New York *Journal of Commerce* says that of Germany's imports of machine tools in 1900, amounting to 6428 tons, 4769 tons were imported from the United States. The monthly average imports from the United States thus amounted to about 397 tons; but the statistics show that the average imports for the first quarter were 475 tons, while in December imports sank to 228 tons. In January, 1901, imports from America further sank to 175 tons. While the imports of machine tools have been rapidly declining, exports have been growing at an equal pace, so that already in 1900 Germany's exports exceeded its imports to 9267 tons. For the first quarter of 1900 the monthly exports amounted to 735 tons, but the average for the whole year reached 770 tons per month; and in January, 1901, the exports rose to 790 tons, or more than three times as much as the total imports for the month.

The German machine tool industry is as nearly an imported industry as can be found anywhere in the world, and it is from the United States that the Germans have equipped themselves with the machinery for turning out machine tools in competition with our own. Anybody going through the great electrical machinery shops of Berlin and other German cities will be surprised to notice the great preponderance of machine tools of American make or design. The Germans, in fact, have done very little in the production of original machinery of this description. Notwithstanding the rapid increase of Germany's exports of machine tools, simultaneously with a rapid decline of imports, German manufacturers are clamoring for increased duties on these goods. It is one of the humorous features of the pronunciamento recently issued by the German makers of machine tools that they argue for an increase of protection by claiming that the German machine tool industry is in all respects equal to the American, and by boasting of the above statistics of imports and exports. The document referred to concludes as follows:—

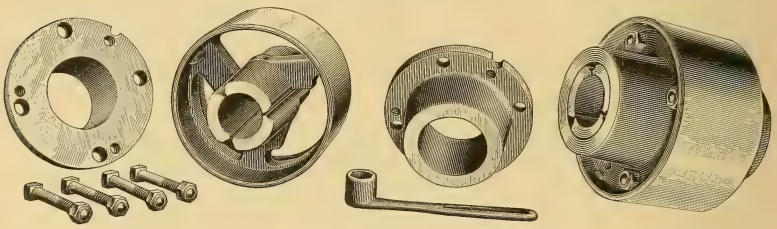
"It is to be expected as a certainty that foreign countries, and particularly America, will make every effort to hold their export market in Central Europe, even at the cost of ruinous prices, if this should be necessary for

getting rid of their surplus production. The tendency of large capital in America to form trusts covering large fields of industrial activity can only assist such a development of things. The German machine tool industry would then receive a most serious blow, if its business should be exposed to such an attack without higher protection, and if it should be weakened by competition in international markets, which is still very active. An adequate duty on machine tools must, therefore, be regarded as an entirely reasonable demand. The American duties, as is well known, are very much higher than the German duties; and this fact has hitherto materially aided in flooding the German market with American machine tools."

The Davis Compression Coupling

THE illustrations on this page show a new invention in the way of a shaft coupling. Each piece of the coupling is shown separately, and the principle will be readily understood. The coupling, as will be seen, consists of the coupling proper, which is made up of a rim with three arms set on an angle, attached to the hub. After the hub is bored it is cut endways in three pieces, each piece being supported by an arm.

The outside of the hub is turned tapering, and the compression flanges also are bored tapering. When these flanges are put on the hub and drawn together by bolts, as shown, the resulting compression brings the shaft into perfect alignment. With this coupling, as shown, no keys are required, and the compression, when the coupling is bolted together, is claimed to be sufficient to hold the shaft securely under the heaviest strain. Any ordinary workman can put the couplings on the shaft and secure them properly in a very few minutes.



A NEW SHAFT COUPLING, MADE BY THE W. P. DAVIS MACHINE CO., ROCHESTER, N. Y.

This will be a great convenience to the average dealer who handles shafting, as the couplings can be shipped out with as little trouble as the shafting, and when received by the customer, they can be put up without any extra fitting.

The coupling can be secured through any machinery or hardware dealer in the United States, or will be shipped direct from the makers,—the W. P. Davis Machine Company, of Rochester, N. Y.

Manufacturing News

A New Railway Inspection Automobile

IN a certain sense the automobile shown in the annexed engraving may be considered a combination vehicle, since, stripped of its pneumatic-tired wheels and provided with another set having inside flanges, it may be used as a light railway inspection car.

The starting point in the evolution of light railway inspection cars in general has been the hand car. Its course has been crossed by the bicycle, and the characteristics of one or the other are predominant. The strains of heredity in the present design seem to have followed the lines of the family carriage, and to have been influenced strongly by the Pullman observation car.

The vehicle illustrated is from the designs of Mr. W. S. Rogers, vice-president of the Roller Bearing & Equipment

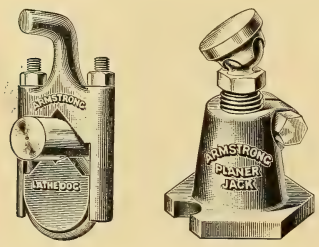
NEW RAILWAY INSPECTION AUTOMOBILE, MADE BY THE STEAMOBILE CO., KEENE, N. H.

Company, of Keene, N. H. The motive power in this instance is steam, there being a 6-H. P. engine supplied by a tubular boiler located underneath the driver's seat and in the box immediately in front of it. In the rear is a tool box, and in front there are lockers on each side. In the middle space in the box and underneath the passengers' seat are located a thirty-six-gallon water tank and a twelve-gallon gasoline tank. The engine cylinders are $3 \times 3\frac{1}{2}$ inches, and the power is transmitted by an extra heavy chain. The weight is 1400 pounds.

The machine complete was built at the works of the Steamobile Company, of Keene, N. H., of which Mr. Rogers is manager.

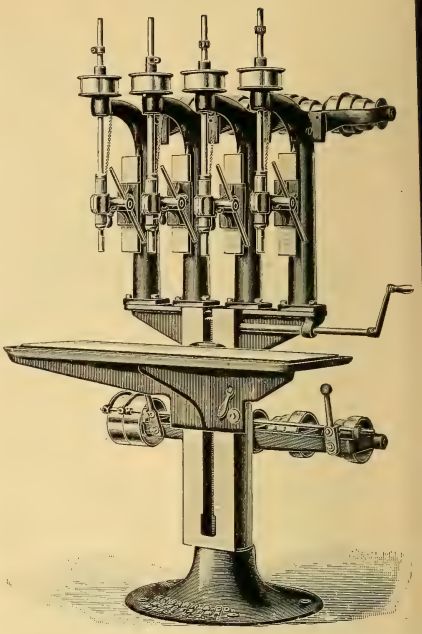
A New Lathe Dog and Planer Jack.

THE Armstrong Brothers Tool Company, of Chicago, have brought out two new specialties, a lathe dog and a planer jack, of which illustrations are given herewith. The dog is so constructed as to combine the convenient features of the clamp dog with the simplicity and strength of the ordinary lathe dog. It will accommodate itself readily to work of any shape, and will hold it securely and squarely, being especially adapted for use on finished work which would be liable to be damaged by the set screw of a common lathe dog. The sliding block is drawn up to the work by a loose-fitting U bolt of steel, threaded on the ends and with case-hardened nuts, loosely fitted, so that they can be run rapidly to size without using a wrench until tightened. The body of the dog is cast of steel, and the design is such that there are no projecting screws or other parts liable to catch the file or the workman's hand or clothing. One advantage of this dog is that it can be adjusted without removing work from centres. It possesses a wide range of adjustment, the seven sizes in which it is made being properly proportioned and balanced to take work from $\frac{1}{8}$ inch up to 5 inches in diameter.



NEW LATHE DOG AND PLANER JACK, MADE BY THE ARMSTRONG BROS. TOOL CO., CHICAGO

The planer jack is designed to displace the hap-hazard devices and methods now generally in use for leveling work on machine tools, and a glance will show any mechanic their convenience and utility. A set of these jacks on a machine will greatly reduce the proportion of time required for preliminary arrangements as compared with the actual machine time on the job, and will, more-



A FOUR-SPINDLE DRILLING MACHINE, MADE BY MESSRS. H. G BARR & CO., WORCESTER, MASS.

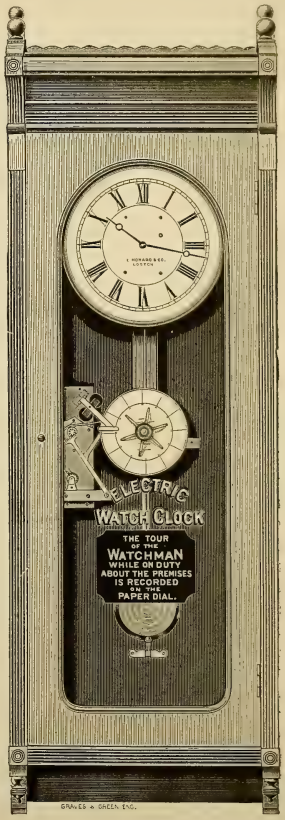
over, by their perfect adjustability and solidity, insure good, true-surfaced work. The base is substantially made of malleable iron, faced true on the bottom; it is of strong design, an important feature being a split hub and screw (case-hardened), providing a convenient means for locking jack screw in position, and of compensating for wear of screw and socket. The tilting cap is of malleable iron, faced on the top, and is attached to head of screw by ball and socket arrangement, which allows it to adapt itself to uneven, irregular or angular surfaces. The screw is made of steel with United States standard thread, and has hexagon neck for wrench. The jacks are made in four sizes.

A New Multiple-Spindle Drilling Machine

ONE of a line of multiple-spindle drilling machines put on the market by Messrs. H. G. Barr & Co., of Worcester, Mass., is shown in the illustration opposite, this being a four-spindle machine. The several tools are highly recommended for rapid drilling and accuracy. All pulleys are turned inside. The driving cones being what are commonly called "two-piece cones," are claimed to be the best constructed pulley known to the trade. The spindle pulleys run on stationary sleeves and do not wear the spindle out of line. All the small posts are connected at the top with a solid yoke. The faces of the posts and column are surfaced to plate and frosted. All sliding surfaces are scraped and fitted. Drifts and chains are attached. The tables are raised with a screw. The makers have sixteen styles of single and multiple spindle drills to select from.

An Electric Watchman's Clock

THE accompanying illustration shows an electric watchman's clock and regulator manufactured by the E. Howard Clock Company, of Boston and New York. This clock is intended to be used where watchmen are employed to record the faithful or unfaithful performance of their duty, and is of such construction that it cannot be tampered with without detection. The clock at which the watchman's record is made can be arranged for any number of watchmen, it being limited only by the space assigned it. Any number of stations can be added or taken from the set of stations without interfering with those which remain. Anyone may have free access to the interior of the clock, and still a record made in any other way than that intended will surely be detected. At the same time the cases are made in the most thorough manner, the door being set in a rabbet and secured



A ELECTRIC WATCHMAN'S CLOCK

with a Yale lock. When desired, a recorder is attached to the door, which prevents its being opened without making a record on the dial. The record is a permanent one which cannot be erased, inasmuch as it is made by punctures through the recording dial which can be preserved for future reference. This is a matter of considerable importance when considering insurance rates.

The clock may be placed in the office, or in any place near to or remote from the watchman's duties, two wires only, running from the clock throughout the building, being necessary for any number of points which the watchman is required to visit on his rounds. A station is placed at every point which the watchman is to visit. Into this he inserts his key, which fits all stations alike, gives a turn, whereupon the station automatically makes the record, and the electric currents are, by contact, allowed to pass through the wire and record the specific number of each at the moment it is visited. The record is made upon a disc of paper. It is not necessary that the stations be visited in any particular order or equal number of times, for the record of each box is given independently of any other, and the route of the watchman may be changed, and the record tells the truth of what has been done by him.

It is claimed for this clock that, unlike others, the stations give them distinctive records without reference to their locations on the receiving disc. Each station is entirely independent of the others, and the failure of any one station to respond has no effect on the working of the others. The system does not require that the watchman should be at a given point at a stated time. A watchman may claim that at a stated time he was detained at some other point in his tour, and as a proof of his statement a record from a neighbouring station may be produced as proof of his veracity; but watchmen are expected to watch the premises and not the clock. This clock, however, has so little to do in locating the time of the records that the time-keeping qualities are in no way impaired.

NAVIGATION is one of the latest fields to be invaded by electricity, and now small launches and even rowboats are being driven by electric motors in an entirely satisfactory manner. In the accompanying illustration is shown a one-half horsepower motor, which is one of a line constructed especially for launch work. As will be observed, the motor is entirely enclosed, being practically moisture proof. If the motor is well protected, or is to be used in fresh water, the weight is materially decreased by the use of aluminum parts, where other metals are not necessary for electrical or magnetic purposes; although, if the motor is likely to be exposed to the salt water, brass or iron fittings are recommended because of the corrosive action of the salt water upon the aluminum. In the latter case the finished parts of the machine are copper-plated for the same reason. The shape of the frame is such that two equal parts are provided for the magnetic flux, one on either side of the armature, a design which allows of great compactness.

An Electric Launch Motor

As the voltage is low the current is necessarily proportionately high, making the design of the brush holder a feature of great importance. The brush holder used with these motors is of the box type, with parallel feed, making it possible to run the motor for a long period of time without any attention to the brushes. A special form of brush is

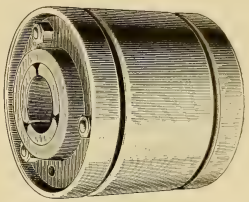
ELECTRIC LAUNCH MOTOR, MADE BY THE HOLTZER-CABOT ELECTRIC CO., BOSTON

used, consisting of stratifications of woven copper gauze and carbon, the outside layers being of the latter substance, with a heavy copper plate. In this way are secured the advantages of the high conductivity of the copper and the wearing qualities of the carbon, the latter also preventing the copper gauze from spreading out and sticking in the holder. A continuous metallic circuit is maintained between the brush and the holder, so that no sliding or imperfect contacts are required to carry current. This makes an extremely efficient and satisfactory brush arrangement for work of this kind, allowing long wear with minimum attention, and making heat losses due to the flow of the current insignificant.

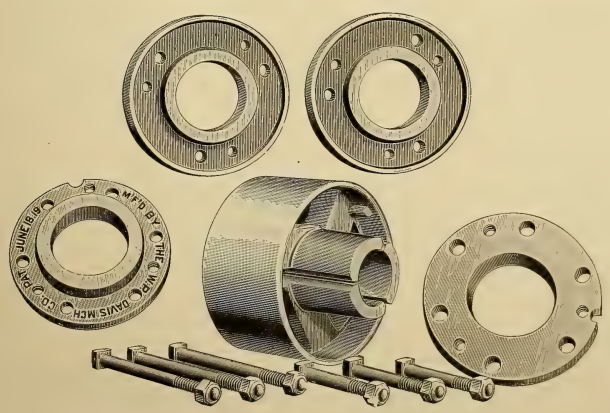
The machines are economical in operation. The speed is low, 1,000 revolutions per minute, and as they are series-wound, they use field energy only in proportion to the load, thus modifying two of the most important sources of waste, namely, friction and heat losses in the windings. The voltage is usually low, from 20 to 40 being ample in most cases, so that there is no possible chance of injury to the operator. The motor is usually supported in the stern of the boat by means of heavy braces, which are bolted to the body of the motor. This line of machines is manufactured by the Holtzer-Cabot Electric Company, of Boston, Mass.

A New Shaft Coupling

A NEW shaft coupling is shown on this page, intended for the larger sizes of shafting, for line shafting from 3 to 8 inches in diameter, where a great amount of power is transmitted. It is made by the W. P. Davis Machine Company, of Rochester, N. Y. The coupling proper is a rim with three arms supporting the hub, which is turned tapering and cut in three equal parts. There are four compression flanges bored in the same taper and fitting the tapering hub. The coupling is first put on the two pieces of shaft, each shaft being pushed into the centre



THE NEW DAVIS SHAFT COUPLING, COMPLETE



DETAILS OF THE COUPLING MADE BY THE W. P. DAVIS MACHINE CO , ROCHESTER N. Y.

of the hub. The first two compression flanges are drawn up securely by three bolts. The two outside flanges are then drawn on by three bolts running through the four flanges, but drawing only the two outside flanges, thereby securing a very powerful compression, sufficient to drive any line shaft for which they are intended.

These couplings have a hub sufficient in thickness to cut a keyway if desired, which allows the use of a key or feather to be placed in the shaft, where parties using them so desire. One of the features of the coupling is the ease with which it is put on the shaft and the perfect alignment secured, as absolute accuracy can be obtained in the running of shaft. Any slight swing to the shaft can be corrected by tightening the bolts on the high side.

All mechanics will appreciate this feature, as all know a flange coupling cannot be made to run true until it is first keyed on the shaft and then faced. The time spent in fitting the ordinary coupling i. often nearly as expensive as the firs cost of the coupling; no fitting whatever is required on this style of compression coupling.

To remove the coupling, the bolts are removed and each of the three bolts are screwed into holes tapped for that purpose in the compression flanges, which forces the flanges off the hub, when the coupling can be slipped off.

The flanges cover the bolt heads and nuts so there is no liability of catching belts or clothing that may come in contact with them when running.

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